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FOUNDATION INVESTIGATION AND DESIGN REPORT

Embankment Widening and RSS Wall Construction
Highway 400 Widening from North of King Road to North of South Canal Bridges, Regional Municipality of York
GWP 2025-13-00

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REPORT

Golder Associates

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FOUNDATION INVESTIGATION REPORT
EMBANKMENT WIDENING AND RSS WALL CONSTRUCTION
HIGHWAY 400 WIDENING FROM NORTH OF KING ROAD TO NORTH OF SOUTH CANAL BRIDGES
REGIONAL MUNICIPALITY OF YORK
GWP 2025-13-00

1.0 INTRODUCTION

Golder Associated Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the detail design of the widening of Highway 400 from north of King Road to South Canal Bank Road in the Region Municipality of York, Ontario.

This report addresses the foundation investigation carried out for the detail design of the widening of high fill embankment areas between Highway 9 and north of South Canal bridges, as well as the construction of a retained soil system (RSS) wall, that form part of Contract 1. Embankments having a height greater than 3.5 m (at and south of about Station 25+120) are addressed in this report, as follows:

- Embankment south of South Canal bridges:
    - NBL: from approximately Station 24+650 to 24+840, and
    - SBL: from approximately Station 24+650 to 24+800.
- Embankment north of South Canal bridges:
    - NBL: from approximately Station 24+900 to 25+120, and
    - SBL: from approximately Station 24+880 to 25+120.
- Construction of the berm between the realigned South Canal and South Canal Bank Road, which is located on the north side of the existing canal.

The purpose of this investigation is to establish the subsurface conditions within the proposed widened embankments by borehole drilling and laboratory testing on selected samples. To supplement the subsurface information obtained for this geotechnical investigation, Boreholes SC-1 to SC-5, SC-7 to SC-11, SC-13, SC-14 and BO-9, advanced as part of the geotechnical investigation for the South Canal bridges, have been used in this report. In addition, the current investigation was also supplemented with information from a previous investigation at this structure site, as follows:

- **MTO GEOCRES No. 31D-029**: Report titled “Foundation Investigation Report for Proposed Extensions to the Overpass Structures at the Crossing of Hwy. #400 and the South Drainage Canal and Road, Township of King – County of York, District No. 6 (Toronto), W.O. 7C-11089 – W.P. 105-70-04”, by the Department of Highways Ontario (DHO), Foundations Section, Materials and Testing Office, dated December 8, 1970.

The previous boreholes as used in this report have been renumbered to show the MTO GEOCRES reference number followed by the original borehole designation. For this site, the boreholes from MTO GEOCRES 31D-029 have been renumbered to “29-X”, where “X” is the original borehole number (i.e., 29-2 to 29-6 and 29-8).

The terms of reference and scope of work for the foundation investigation are outlined in MTO’s Request for Proposal (RFP) dated May 2008, and MTO’s revised Terms of Reference an Addendum dated October 14, 2011. The scope of work for the foundation engineering services is presented in Section 6.8 of URS’s *Technical Proposal* for this assignment and Golder’s scope change letter, dated November 11, 2011. The work has been carried out in accordance with Golder's Supplemental Specialty Quality Control Plan for this project, dated October 2010.

2.0 SITE DESCRIPTION

The Contract 1 widening of Highway 400 will result in the extension of the embankments on the east and west sides of Highway 400 from about 130 m south of the South Canal bridges to 200 m north of the South Canal bridges in King Township, in the Regional Municipality of York. Within the study area, the South Canal bridges (northbound and southbound) are located approximately 0.5 km north of Highway 9 and span over an approximately 18 m wide excavated canal and South Canal Bank Road. Both bridges consist of six-span structures constructed in 1948, with the original structure supported on driven timber piles. The bridges were widened toward the outside in 1971, with the widened portion supported on driven steel H-piles. Highway 400 in the vicinity of South Canal bridges has been constructed on embankment fill that is approximately 5 m to 7 m high. North of the South Canal bridges, the embankments on the east and west side of the highway gradually reduce in height, such that they are about 1 m to 2 m high at a point about 200 m north of the South Canal bridges. South Canal Bank Road, located on the north side of the canal, is about 1.5 m above the water level of the canal. On the east and west sides of Highway 400, Davis Drive and Wist Road, respectively, extend north from South Canal Bank Road to the project limits.

North of Highway 9, the ground surface slopes downward from the Oak Ridges Moraine to the Holland Marsh; the grade of Highway 400 gradually decreases from about Elevation 240 m at Highway 9 to about Elevation 227 m at the South Canal bridges to about Elevation 222 m at the north limit of the high fill embankment widening area.

In general, the study area is forested south of the South Canal bridges and generally flat lying north of the South Canal bridges. The land use along Davis Drive, Wist Road and South Canal Bank Road is generally mixed residential and agricultural.

The embankment slopes along Highway 400 are generally inclined at about 2 horizontal to 1 vertical (2H:1V), with the slope faces typically well vegetated. No evidence of embankment or pavement settlement or slope instability was observed within the existing embankment areas at the time of the borehole investigation.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out between January and April 1, 2011 and in May and June, 2012 during which time a total of twenty boreholes (Boreholes F8-1 to F8-6, and Boreholes12-1 to 12-14) were advanced at the locations shown on Drawings 1, 3 and 5. In general, the boreholes were configured to be spaced at approximately 50 m intervals along the high embankment fill section, with some of the boreholes advanced through the existing Highway 400 shoulder, some at the toes of the embankment and some on either side of the canal, east and west of Highway 400. Boreholes 12-1 and 12-2 were advanced within the canal using a D-25 drill rig mounted on a barge, while the remaining boreholes were advanced using a D-25 or D-50 drill rig, supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes were advanced through the overburden using either 108 mm inside diameter hollow stem augers or wash boring techniques using 76 mm outer diameter NW casing.

Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using 50 mm outside diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedure (ASTM D). (ASTM D1586-08a – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of the Soil). In situ field vane testing, using MTO standard “N”-size vanes, was carried out in boreholes where soft to stiff cohesive soils were encountered to measure the undrained shear strength of the cohesive deposits. Thin-walled Shelby tube samples (ASTM) were also obtained within the cohesive materials at selected intervals.

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations and a piezometer was installed in Borehole 12-6 to permit monitoring of the water level at this location. The piezometer consists of 50 mm diameter PVC pipe, with a slotted screen sealed at a select depth within the borehole. Above the sand filter pack and piezometer screen, the annulus surrounding the piezometer pipe was backfilled to the ground surface with bentonite pellets/grout.

Piezometer installation details and water level readings obtained during and following the borehole drilling are described on the Record of Borehole sheets following the text of this report. Boreholes where artesian groundwater conditions were noted were backfilled with cement grout and all other remaining boreholes were backfilled with bentonite, upon completion, in accordance with Ontario Regulation 903 (as amended).

The field work was observed by members of Golder’s engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing of selected samples. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Index and classification testing (water content, Atterberg limits and grain size distributions) were carried out on selected soil samples. In addition, four one-dimensional consolidation (oedometer) tests were carried out on selected samples of the cohesive deposits.

The borehole locations were established in the field by Golder personnel relative to site features. The ground surface elevation at each borehole was estimated from the digital terrain model for the site as provided by URS.

In addition to the boreholes drilled specifically for this investigation, twelve boreholes advanced for the South Canal Bank Road overpass investigation (Boreholes SC-1 to SC-5, SC-7 to SC-11, SC-14 and BO-9) and six boreholes from the previous MTO investigation (GEOCRES No. 31D-029: Boreholes 29-2 to 29-6 and 29-8) have also used in the assessment of the subsurface stratigraphy for the embankment widening in Contract 1.

The borehole locations (referenced to the MTM NAD83 co-ordinate system), ground surface elevations (referenced to geodetic datum) and drilled depths are summarized below and are shown on Drawings 1 to 5.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
12-1	4,877,101.4	297,123.6	219.0*	13.6
12-2	4,877,138.4	297,168.4	219.0*	13.7

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
12-3	4,877,222.9	297,142.4	225.0	18.9
12-4	4,877,275.6	297,148.2	219.5	19.9
12-5	4,877,314.1	297,119.9	223.5	21.9
12-6	4,877,363.4	297,126.5	219.7	23.5
12-7	4,877,186.9	297,096.2	220.4	20.3
12-8	4,877,236.1	297,100.5	224.1	21.9
12-9	4,877,276.8	297,071.9	219.5	23.5
12-10	4,877,324.8	297,075.2	222.0	20.4
12-11	4,877,137.4	297,197.1	219.5	10.7
12-12	4,877,173.1	297,222.1	219.0	12.8
12-13	4,877,053.3	297,098.6	219.3	14.3
12-14	4,877,039.6	297,057.1	219.2	14.3
F8-1	4,877,001.3	297,209.6	227.3	6.4
F8-2	4,877,031.6	297,183.6	229.2	15.8
F8-3	4,877,098.8	297,187.5	221.0	6.7
F8-4	4,876,920.8	297,144.9	227.0	6.6
F8-5	4,876,957.9	297,131.3	223.8	9.4
F8-6	4,877,028.4	297,140.7	229.1	17.2
SC-1	4,877,070.0	297,189.1	223.0	12.8
SC-2	4,877,082.3	297,188.1	222.0	17.4
SC-3	4,877,124.8	297,177.2	220.1	17.2
SC-4	4,877,151.8	297,171.4	220.8	27.9
SC-5	4,877,176.1	297,165.0	221.1	15.9
SC-7	4,877,117.8	297,113.1	220.7	40.1
SC-8	4,877,130.1	297,103.5	220.5	12.8
SC-9	4,877,070.2	297,116.5	221.0	20.4
SC-10	4,877,033.5	297,122.5	222.1	15.9
SC-11	4,877,019.1	297,122.9	221.8	14.3
SC-14	4,877,041.9	297,120.6	222.0	18.1
BO-9	4,877,161.8	297,169.1	221.0	26.5
29-2	4,877,083.0	297,134.0	223.9	18.3
29-3	4,877,114.0	297,164.0	220.6	13.9
29-4	4,877,119.0	297,129.0	221.1	16.9
29-5	4,877,149.0	297,157.0	221.1	20.0
29-6	4,877,146.0	297,122.0	225.8	20.3
29-8	4,877,128.0	297,143.0	221.1	20.3

* denotes elevation of water in the canal

4.0 SUBSURFACE CONDITIONS

4.1 Regional Geology

The 13 km long section of Highway 400 included in the overall project site traverses, in a south–north direction, the physiographic regions known as South Slope, Oak Ridges Moraine and Simcoe Lowland, according to *The Physiography of Southern Ontario (Chapman and Putman, 1984)*[1]. Along Highway 400, the South Slope is present south of King Road, the Oak Ridge Moraines extends from north of King Road to south of Highway 9 and the Simcoe Lowlands occupy a 4 km wide strip extending from south of Highway 9 to the Holland Marsh. The highway embankment area north and south of the South Canal bridges is located within the Simcoe Lowlands physiographic region.

The surficial soils of the South Slope region are generally cohesive tills. The Oak Ridges Moraine predominately consists of sand and gravel, although in the King Township area these soils are often overlain by till. It is understood that during grading for the initial construction of Highway 400 in this area, cuts exposed up to about 10 m of till overlying sand and gravel deposits.

The Holland River valley, which crosses Highway 400 in the vicinity of Highway 9 and South Canal Bank Road, is located within the Simcoe Lowlands region. This valley extends south west from Cook Bay, at the south end of Lake Simcoe, and was once a shallow extension of the lake. The floor of the valley consists of peat, soft clays and loose sands. It is understood that during initial construction of Highway 400, a layer of peat about 2 m to 3 m thick was removed in order to construct the road upon the underlying sand and clay.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2 Subsurface Conditions

As part of the subsurface investigation, twenty boreholes were advanced within the proposed high fill embankment widening areas, supplemented by twelve boreholes drilled for different aspects of the Highway 400 assignment and six boreholes from a previous MTO investigation. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawings 1 to 5.

The detailed subsurface soil and groundwater conditions encountered in the boreholes as part of the current investigations, together with results of the in situ and laboratory tests carried out on selected soil samples are provided on the borehole records following the text of this report; the results of the geotechnical laboratory testing are also presented in Appendices A, B and C. The borehole information and laboratory test results from the previous MTO investigation are presented in Appendix D. The results of the in situ field tests (i.e., SPT “N” values and undrained shear strengths from field vane testing) as presented on the borehole records and in the following sections of this report are uncorrected.

The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profiles on Drawings 2, 4 and 5 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather

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[1] Chapman, L.J. and Putnam, D,F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P. 2715, Scale 1:600,000.

than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

The subsurface conditions encountered in the embankment widening south of the existing South Canal are different than the subsurface conditions encountered north of the South Canal and therefore they are presented separately in Sections 4.3 and 4.4, respectively.

4.3 Embankment Widening – SBL (Station 24+650 to 24+800) and NBL (Station 24+650 to 24+840)

This section of proposed embankment widening is located immediately south side of the South Canal bridges, on the east and west sides of the existing Highway 400 embankment. The existing bridges and the Highway 400 embankment in this area are located where the highway slopes downward from the “tableland” south of Highway 9, into the Holland Marsh. The South Canal crosses under the existing South Canal bridges adjacent to the north limit of this embankment section. The ground surface at the crest of the existing embankment is at about Elevation 229 m, and about Elevation 222 m at the embankment toes. Boreholes F8-1 to F8-6 were advanced within the limits of this embankment. Boreholes SC-1, SC-2, SC-10, SC-11, and SC-14 were drilled as part of an investigation completed by Golder for the replacement of the South Canal bridges and also lie within the limits of the embankment. The locations of the boreholes and the interpreted stratigraphic profiles along the SBL and NBL widening are shown on Drawings 1 and 2. The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced for this investigation and the results of in situ and laboratory tests carried out on selected soil samples are provided in Appendix A.

In summary, the subsoils encountered in the boreholes in the area immediately south of the South Canal bridges consist of a layer of topsoil or asphalt underlain by fill and thin deposits of clayey silt and sand and silt. These deposits are underlain by cohesive and non-cohesive glacial till deposits. The non-cohesive till deposits generally extend over the western limit of the proposed embankment area.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.3.1 Topsoil and Asphalt

An approximately 100 mm to 200 mm thick layer of topsoil was encountered immediately below the existing ground surface in Boreholes F8-1, F8-3, F8-4, SC-1, SC-2, SC-10, SC-11 and SC-14 which were advanced at or near the toe of the existing high fill embankment.

An approximately 100 mm to 300 mm thick layer of asphalt was encountered beneath the road surface in Boreholes F8-2 and F8-6 which were advanced at the crest of the high fill embankment on the Highway 400 shoulders.

4.3.2 Fill

Fill was encountered below the asphalt and topsoil layers or at ground surface in all boreholes except Boreholes SC-2, SC-10 and SC-14. The elevations of the surface and base of the fill deposit and the deposit thicknesses as encountered in the boreholes are summarized below.

Borehole No.	Depth to Fill Surface (m)	Fill Surface Elevation (m)	Fill Thickness (m)	Fill Base Elevation (m)
F8-1	0.2	227.1	2.0	225.1
F8-2	0.3	228.9	5.3	223.6
F8-3	0.2	220.8	3.1	217.7
F8-4	0.2	226.8	1.4	225.4
F8-5	0.0	223.8	1.5	222.3
F8-6	0.1	229.0	8.6	220.4
SC-1	0.2	222.8	1.3	221.5
SC-11	0.1	221.7	2.2	219.6

Boreholes F8-2 and F8-6 were advanced from the road surface and penetrated fully through the existing Highway 400 high fill embankment, whereas the remaining boreholes were advanced through fill that had been placed at or near the toes of the existing embankment.

The embankment fill consists mainly of cohesive soil but also consists of sand and gravel below the asphalt pavement and silty sand to sand and gravel within the embankment. Rootlets and/or organics were noted within the fill deposit in Boreholes F8-1, F8-3 to F8-5, SC-1 and SC-11.

The measured SPT ‘N’ values within the fill deposit range from 4 blows to 48 blows per 0.3 m of penetration; however, they typically range from 8 blows to 25 blows per 0.3 m of penetration, indicating a generally loose to compact relative density within the non-cohesive portions of the fill and a stiff to very stiff consistency within the cohesive fill.

The results of six grain size distribution tests performed on samples of the fill are shown on Figure A1 in Appendix A.

Atterberg limits testing carried out on five samples from the cohesive portions of the fill measured liquid limits ranging from 18 per cent to 27 per cent, plastic limits ranging from 13 per cent to 14 per cent and plasticity indices ranging from 5 per cent to 13 per cent. The test results, which are plotted on a plasticity chart on Figure A2 in Appendix A, indicate that this portion of the fill material is a clayey silt of low plasticity. The natural water content measured on samples of the cohesive fill ranges from about 10 per cent to 20 per cent.

4.3.3 Sandy Silt to Sand and Gravel

Deposits of silty sand to sand and gravel were encountered in Boreholes F8-5, SC-1, SC-2, SC-10, S-11 and SC-14.The sandy silt to sand and gravel deposits were contacted at depths between 0.2 m and 2.7 m below ground surface (Elevation 217.3 m to Elevation 222.2 m) and the thickness of these deposits ranges from 0.4 m to 2.3 m at the borehole locations.

The deposits vary from sandy silt to sand and gravel containing varying amounts of clay. Organic material and wood fragments were noted within these deposits in Boreholes SC-1, SC-2, and SC-11.

The measured SPT ‘N’ values within the deposit range from 2 blows to 44 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The results of four grain size distribution tests performed on samples of the sandy silt to sand and gravel are shown on Figure A3 in Appendix A. The measured natural water content of four samples of the sandy silt to sand and gravel deposit from the current investigation range from 11 per cent to 24 per cent.

4.3.4 Clayey Silt (Upper Deposit)

An upper deposit of clayey silt was encountered underlying the fill in Boreholes F8-2, F8-3, F8-4 and SC-1, below the topsoil in Boreholes SC-2 and SC-10 and below the sandy silt in Borehole SC-14.

The upper clayey silt deposit was contacted at depths between 0.1 m and 5.6 m below ground surface (Elevation 217.3 m to Elevation 225.4 m) and the thickness of these deposits ranges from 0.4 m to 4.0 m at the borehole locations.

The clayey silt deposit contains varying amounts of sand and gravel, and organic materials were noted within the layers in Boreholes F8-2, F8-3, SC-1, SC-10 and SC-14.

The measured SPT ‘N’ values within the deposit range from 3 blows to 44 blows per 0.3 m of penetration, suggesting a soft to hard consistency for the overall deposit, but are typically between 8 blows and 25 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

The results of three grain size distribution tests performed on samples of the upper clayey silt are shown on Figure A4 in Appendix A.

Atterberg limits tests were carried out on three samples of the clayey silt deposit from the current investigation and the measured liquid limits ranged between 19 per cent and 28 per cent, plastic limits ranging between 11 per cent and 16 per cent and plasticity indices ranging between 8 per cent and 12 per cent. These test results which are plotted on a plasticity chart on Figure A5, indicate that this material is a clayey silt of low plasticity.

An organic content test carried out on a sample of the clayey silt measured 1.8 per cent organics. The measured natural water content measured on twelve samples of the clayey silt deposit from the current investigation ranges between 12 per cent and 26 per cent.

4.3.5 Organic Sandy Silt / Peat

A layer of organic sandy silt / peat was encountered below the fill in Borehole F8-6 and below the upper clayey silt in Boreholes SC-1, SC-2, SC-10 and SC-14. The sandy silt to sand and gravel deposits were contacted at depths between 0.2 m and 2.7 m below ground surface and the thickness of these deposits ranges from 0.4 m to 2.3 m at the borehole locations.

The result of one grain size distribution test performed on a sample of the organic sandy silt is shown on Figure A6 in Appendix A. An organic content test carried out on a sample of the organic sandy silt / peat measured 7 per cent organics.

4.3.6 Silt to Clayey Silt (Lower Deposit)

A lower deposit of silt to clayey silt was encountered below the sandy silt to silty sand till in Borehole F8-1 and below the sandy silt to sand and gravel in Boreholes SC-10, SC-11 and SC-14. The surface of this deposit was encountered at depths ranging from 2.6 m to 4.9 m below ground surface (Elevation 222.4 m to 218.4 m) and the deposit is about 1.1 m to 3.5 m thick. Borehole F8-1 was terminated within the lower silt to silty clay deposit at a depth of 6.4 m below ground surface (Elevation 220.9 m) after penetrating 1.5 m into the layer.

The measured SPT ‘N’ values measured within the lower silt to silty clay deposit range from 8 blows to 138 blows per 0.3 m of penetration, suggesting a stiff to hard consistency.

The results of one grain size distribution test performed on a sample of the lower clayey silt to silty clay are shown on Figure A7 in Appendix A.

Atterberg limits tests were carried out on four samples of the lower silt to silty clay deposit measured liquid limits ranging from 14 per cent to 31 per cent, plastic limits ranging from 10 per cent to 18 per cent and plasticity indices ranging from 4 per cent to 15 per cent. These test results, which are plotted on a plasticity chart on Figure A8 in Appendix A, indicate that this material is silt of slight plasticity to clayey silt of low plasticity. The measured natural water contents of four samples of the lower silt to clayey silt from the current investigation ranges from 14 per cent to 26 per cent.

4.3.7 Clayey Silt Till

A deposit of clayey silt till was encountered below the fill in Borehole F8-1, below the upper clayey silt in Boreholes F8-2 and F8-3, below the lower clayey silt in Boreholes SC-10 and SC-14 and below the sandy silt to sand and gravel in Boreholes SC-1, SC-2 and SC-11. The clayey silt till was contacted at depths between 2.2 m and 7.2 m below ground surface (Elevation 214.9 m to Elevation 225.1 m) and the thickness of this deposit ranges from 1.5 m to greater than 12.8 m at the borehole locations.

Boreholes F8-2, F8-3, SC-1, SC-10, SC-11 and SC-14 were terminated within the clayey silt till. The till deposit consists of clayey silt containing varying amounts of sand and gravel. Cobbles and boulders are present within this layer, inferred by the bouncing of a split-spoon sampler in Borehole SC-1.

The measured SPT ‘N’ values within the clayey silt till range from 6 blows per 0.3 m of penetration to 133 blows per 0.23 m of penetration and generally increase with depth. These ‘N’ values suggest that the till deposit has a firm to hard consistency.

The results of nine grain size distribution tests performed on samples of the clayey silt till are shown on Figures A9A and A9B in Appendix A.

Atterberg limits tests were carried out on sixteen samples of the clayey silt till deposit and measured liquid limits ranging from 16 per cent to 21 per cent, plastic limits ranging from 10 per cent to 13 per cent and plasticity indices ranging from 3 per cent to 11 per cent. These test results, which are plotted on the plasticity charts on Figures A10A and A10B in Appendix A, indicate that this material is a clayey silt of low plasticity. The measured natural water content of thirty-four samples of the clayey silt till from the current investigation ranges from 7 per cent to 25 per cent, typically near the plastic limit of the material.

4.3.8 Sandy Silt to Silty Sand Till

A deposit of sandy silt to silty sand till was encountered below the upper clayey silt in Borehole F8-4, below the organic sandy silt / peat layer in Borehole F8-6, below sand and silt in Borehole F8-5 and below clayey silt till in Boreholes F8-1 and SC-2. The sandy silt to silty sand till was contacted at depths between 3.7 m and 13.9 m below ground surface (Elevation 208.1 m to Elevation 223.6m) and the thickness of this deposit ranged from greater than 1.0 m to greater than 7.7 m at the borehole locations.

All boreholes noted above were terminated within the sandy silt to silty sand till deposit except Borehole F8-1. The till deposit typically contains trace clay and trace to some gravel. Cobbles and boulders were also noted within the deposit, inferred by the grinding of augers as they advanced through the deposit, as noted on the borehole records.

The SPT ‘N’ values measured within the non-cohesive till deposit range from 40 blows per 0.3 m of penetration to 100 blows per 0.1 m of penetration, indicating a dense to very dense relative density.

The results of five grain size distribution tests performed on samples of the sandy silt to silty sand till deposit are shown on Figure A11 in Appendix A. The natural water content of nine samples of the sandy silt to silty sand till deposit ranges from 3 per cent to 15 per cent.

4.3.9 Groundwater Conditions

The observed/recorded water levels in the open boreholes following completion of drilling and in the standpipe piezometer installed in Borehole SC-1 are shown on the borehole records and are summarized as follows:

Borehole / Piezometer	Ground Surface Elevation (m)	Depth to Groundwater Level (m)	Groundwater Level Elevation (m)	Date	Notes
F8-1	227.3	4.4	222.9	Jan. 18, 2011	Open Borehole
F8-2	229.2	15.2	214.0	Apr.1, 2012	Open Borehole
F8-3	221.0	3.2	217.8	Jan. 18, 2012	Open Borehole
F8-4	227.0	2.7	224.3	Apr.4, 2012	Open Borehole
F8-5	223.8	1.6	222.2	Apr. 7, 2012	Open Borehole
F8-6	229.1	14.9	214.2	Mar. 31, 2012	Open Borehole
SC-1	223.0	2.8 0.3	220.2 222.7	Jun. 11, 2012 Jun. 12, 2012	Open Borehole Piezometer
SC-2	222.0	2.0 ags*	224.0	Jun. 8, 2012	Inside Casing
SC-10	222.1	2.1	220.0	May 14, 2012	Open Borehole
SC-11	221.8	Dry	-	May 11, 2012	Open Borehole
SC-14	222.0	3.7	218.3	May 22, 2012	Open Borehole

*ags = above ground surface

Artesian groundwater conditions were encountered within the lower non-cohesive till deposit primarily on the east side of the fill embankment. The groundwater in the casing rose to 2.0 m above ground surface during drilling operations in Borehole SC-2.

The water levels observed in the open boreholes on completion of drilling and in the piezometer may not represent long-term stabilized groundwater levels. The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.

4.4 Embankment Widening – SBL (Station 24+880 to 25+120) and NBL (Station 24+900 to 25+120)

Boreholes 12-3 to 12-10 were advanced within the limits of this embankment area during the current investigation. In addition to the boreholes drilled specifically for the high fill embankment investigation, Boreholes SC-5, SC-7, SC-8, BO-9, 29-5 and 29-6 from previous investigations with the site limits have also been used in the assessment of the subsurface stratigraphy for this section of the embankment widening. The detailed subsurface soil and groundwater conditions encountered in the boreholes from the current investigation and the results of in situ and laboratory tests carried out on selected soil samples are provided in Appendix B; the results of boreholes from the previous investigation by others are included in Appendix D. The borehole locations and the interpreted stratigraphic profiles along the SBL and NBL widening are shown on Drawings 3 and 4, respectively.

In general, the subsurface conditions at the site consist of surficial layers of topsoil, asphalt and roadway base granular fill and cohesive fill in the vicinity of Highway 400, underlain by a clayey silt to silty clay deposit with silty sand to sandy silt interlayers. The clayey silt to silty clay deposit is underlain by a sand and silt till to clayey silt till deposit. A silty sand to sand and gravel deposit with clayey silt interlayers underlies the till deposit.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.4.1 Topsoil and Asphalt

Approximately 100 mm to 500 mm of topsoil was encountered immediately below the existing ground surface in Boreholes 12-7, SC-8, and BO-9. These boreholes were drilled at the embankment toes of Highway 400.

An approximately 100 mm to 300 mm thick layer of asphalt was encountered beneath the road surface in Boreholes 12-3, 12-5, 12-8, 12-10 and SC-5 which were advanced at the crest of the high fill embankment on the Highway 400 shoulders. A 100 mm layer of asphalt was encountered in Borehole 12-6 and SC-5 which were advanced at the base of the South Canal bridges embankment on the side of Wist Road.

4.4.2 Fill

Fill consisting of sand and gravel, clayey silt and sand and silt to silty sand was encountered in all of the boreholes advanced for the widening of the embankment north of the north approach to the South Canal bridges and is described in more detail below.

4.4.2.1 *Sand and Gravel Fill*

A 0.6 to 1.5 m thick layer of sand and gravel fill was encountered below the asphalt in Boreholes 12-3, 12-5, 12-6, 12-8 and 12-10 and at ground surface in Borehole 12-4. The fill layer typically contains some silt and trace clay. Organics were noted to be present within this layer in Borehole 12-4.

4.4.2.2 *Clayey Silt Fill*

Clayey silt fill was encountered below the asphalt and topsoil layers or at ground surface in Boreholes 12-4, 12-6, 12-7, 12-9, SC-7, 29-5 and 29-6, below sand and gravel fill in Boreholes 12-3, 12-5, 12-8, 12-10 and below sand and silt to silty sand fill in Borehole SC-5.

The elevation of the surface and base of the clayey silt fill deposit and the deposit thickness as encountered in the boreholes are summarized below.

Borehole No.	Depth to Clayey Silt Fill Surface (m)	Clayey Silt Fill Surface Elevation (m)	Clayey Silt Fill Thickness (m)	Clayey Silt Fill Base Elevation (m)
12-3	1.2 4.6	223.8 220.4	1.4 1.8	222.4 218.6
12-5	1.5	222.0	1.5	220.5
12-7	0.5	219.9	0.2	219.7
12-8	1.5 4.5	222.6 219.6	2.2 2.9	220.4 216.7
12-9	0.0	219.5	0.6	218.9
12-10	1.6	220.4	3.6	216.8
SC-5	0.4	220.7	0.3	220.4
SC-7	0.8	220.7	0.8	219.9
29-5	0.0	221.1	0.9	219.2
29-6	0.0	225.8	3.3	222.5

The clayey silt fill layer contains varying amounts of sand and gravel and layers of silty sand were noted in Boreholes 12-3 and 12-5. Organics were also noted to be present within the fill layer in Boreholes 12-3, 12-7, 12-9, SC-7, 29-4, and 29-5.

The measured SPT ‘N’ values within the fill deposit range from 2 blows to 27 blows per 0.3 m of penetration, however, typically range from 4 blows to 15 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.

The result of one grain size distribution test performed on a sample from the previous investigation is shown on the borehole record in Appendix D. The results of Atterberg limits testing carried out on a sample of the clayey silt fill from the previous investigation are also shown on the borehole record. The measured natural water content measured on samples of the clayey silt fill from the current investigation ranges from approximately 10 per cent to 20 per cent.

4.4.2.3 *Sand and Silt to Silty Sand Fill*

Sand and silt to silty sand fill was encountered below asphalt in Borehole SC-5 and below the clayey silt fill in Boreholes 12-3, 12-5 and 12-8. The elevation of the surface and base of the clayey silt fill deposit and the deposit thickness as encountered in the boreholes are summarized below.

Borehole No.	Depth to Non-Cohesive Fill Surface (m)	Non-Cohesive Fill Surface Elevation (m)	Non-Cohesive Fill Thickness (m)	Non-Cohesive Fill Base Elevation (m)
12-3	2.6	222.4	2.0	220.4
12-5	3.0	220.5	4.2	216.3
12-8	3.7	220.4	0.8	219.6
SC-5	0.1	221.0	0.3	220.7

The sand and silt to silty sand fill typically contains trace clay and trace gravel. The measured SPT ‘N’ values within the fill layer range from 3 blows to 40 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The results of two grain size distribution tests performed on samples of the sand and silt to silty sand fill are shown on Figure B1 in Appendix B.

Atterberg limits testing carried out one sample of the sand and silt fill from the current investigation measured a liquid limit of 17 per cent, a plastic limit of 13 per cent and a plasticity index of 4 per cent. The test result, which is plotted on a plasticity chart on Figure B2 in Appendix B, indicates that the fill material is a silt of low plasticity.

4.4.3 Organic Clay / Peat

A layer of organic clay / peat was encountered below the sand and gravel fill in Boreholes 12-4 and 12-6, below the clayey silt fill in Boreholes 12-7, 12-9, SC-5, SC-7 and 29-5 and below clayey silt in Boreholes SC-8 and BO-9. The organic clay / peat was encountered at depths ranging from 0.6 m to 1.8 m below ground surface (Elevation 220.4 m to 218.7 m) and is 0.5 m to 2.2 m thick. The organic clay / peat was typically encountered in the boreholes advanced at the base of the Highway 400 embankment and was not encountered in the boreholes advanced through the existing Highway 400 embankment.

The organic clay / peat is typically silty and contains rootlets and wood fragments.

The measured SPT ‘N’ values within the organic clay / peat range from 1 blow to 9 blows per 0.3 m of penetration, but typically range between 1 blow and 5 blows per 0.3 m of penetration, suggesting a very soft to firm consistency for the cohesive portions of the layer and a very loose to loose relative density for the non-cohesive portions.

Organic content tests performed on four selected samples of the organic clay / peat showed 18 per cent to 35 per cent organics.

4.4.4 Silty Sand (Upper Deposit)

A 0.1 m to 0.9 m thick upper layer of silty sand was encountered below the fill in Boreholes 12-8 and 29-6. The upper silty sand deposit was encountered at depths of 7.4 m and 3.4 m below ground surface (Elevation 216.7 m and 222.5 m). The upper silty sand layer typically contains trace clay and trace gravel.

The measured SPT ‘N’ values measured within the upper silty sand were 9 blows and 66 blows per 0.3 m of penetration, indicating a loose to very dense relative density.

4.4.5 Clayey Silt to Silty Clay

Clayey silt to silty clay was encountered in all boreholes advanced within the embankment area. The clayey silt was encountered at depths ranging from 0.1 m to 7.5 m below ground surface (Elevation 216.3 m to 220.9 m). Boreholes 12-3, 12-5, 12-8, 12-10 and SC-8 were terminated in the clayey silt.

The clayey silt to silty clay deposits typically contains trace to some sand. Seams or interlayers of sandy silt to silty sand were noted to be present in Boreholes 12-3 to 12-10, SC-5, SC-7, SC-8, BO-9 and 29-6. Trace quantities of organic material are present within the upper potions of the clayey silt to silty clay in Boreholes 12-3, 12-6, SC-8 and BO-9.

The measured SPT ‘N’ values within the clayey silt to silty clay deposits range from 0 blows (weight of the SPT hammer advancing the sampler) to 52 blows per 0.3 m of penetration, but typically range from 1 blow to 15 blows per 0.3 m of penetration, suggesting a generally very soft to stiff consistency. Vane shear tests performed within the clayey silt to silty clay deposit yielded results ranging from 8 kPa to greater than 163 kPa (vane torque refusal) but typically ranging from approximately 20 kPa to 50 kPa, indicating a soft to firm consistency.

The results of nineteen grain size distribution tests performed on samples of the upper deposit of clayey silt to silty clay from the current investigation are shown on Figures B3A, B3B and B3C in Appendix B. The result of a grain size distribution test performed on a sample of the clayey silt to silty clay from the previous investigation is shown on the borehole record in Appendix D.

Atterberg limits testing carried out on forty-seven samples of the clayey silt to silty clay from the current investigation measured liquid limits ranging from 15 per cent to 37 per cent, plastic limits ranging from 9 per cent to 18 per cent and plasticity indices ranging from 3 per cent to 20 per cent. The test results, which are plotted on plasticity charts on Figures B4A to B4H in Appendix B, indicate that the material is clayey silt of low plasticity to silty clay of intermediate plasticity. Atterberg limits testing carried out on samples of clayey silt from the previous investigation are shown on the borehole records in Appendix D. The measured natural water content on samples from the current investigation typically ranges from about 15 per cent to 35 per cent.

An organic content test performed on a sample of the upper portion of the clayey silt to silty clay deposit measured 1 per cent organic material.

Laboratory consolidation tests were carried out on five thin-walled Shelby tube samples of the clayey silt to silty clay deposit. The consolidation test results are presented on Figures B5 to B9 in Appendix B and are summarized below.

Borehole/ Sample No.	Sample Depth/Elev. (m)	Unit Weight (kN/m^3)	σ_{vo}' (kPa)	σ_p' (kPa)	σ_p' - σ_{vo}' (kPa)	OCR	e_o	C_c	C_r	C_v* cm^2/s
12-4 / S6	215.5	21.9	31	116	85	3.7	0.44	0.10	0.025	1.3x10^{-3}
12-6 / S15	203.4	18.3	145	196	51	1.4	1.05	0.39	0.025	3.5x10^{-3}
12-7 / S10	203.3	19.4	83	189	106	2.3	0.81	0.24	0.025	1.9x10^{-3}
SC-5 / T1	12.4 / 208.7	20.1	109	135	26	1.2	0.64	0.16	0.022	2.1x10^{-3}
SC-7 / 11	11.0 / 209.7	20.6	96	150	54	1.6	0.63	0.16	0.026	1.1x10^{-3}

Notes: * for approximate stress range 20 ≤ σ ≤ 150 kPa

where	σ_p'	Estimated preconsolidation stress	σ_{vo}'	Computed existing vertical effective stress
	C_c	Compression index	C_r	Recompression index
	e_o	Initial void ratio	OCR	Overconsolidation ratio
			C_v	Coefficient of consolidation (cm^2/s) in the normally consolidated range

4.4.6 Silt to Silty Sand Interlayers

Discontinuous silt to silty sand interlayers, approximately 0.1 m to 2.6 m thick, were encountered within the clayey silt to silty clay deposit in all boreholes except Borehole 29-5. The interlayers consist of silt to silty sand and typically contain trace clay. Organics were noted to be present within some of the upper interlayers in Boreholes 12-3, 12-5 and 12-6.

The measured SPT ‘N’ values within the sandy silt to silty sand interlayers range from 0 blows to 23 blows per 0.3 m of penetration, but are generally between 5 blows and 15 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The results of grain size distribution testing completed on five samples of the silt to silty sand interlayers are shown on Figure B10 in Appendix B. Atterberg limits testing carried out on one sample of the silt interlayers measured a liquid limit of 15 per cent, a plastic limit of 12 per cent and plasticity index of 3 per cent. The results, which are plotted on Figure B11 in Appendix B, indicate that the material is a silt of slight plasticity.

4.4.7 Clayey Silt Till

A deposit of clayey silt till was encountered underlying the clayey silt to silty clay deposit in Boreholes SC-5 and SC-7. Borehole SC-5 was terminated at a depth of 15.9 m (Elevation 205.3 m) after penetrating 1.1 m into the deposit. The surface of till was encountered at a depth of 13.7 m (Elevation 207.0 m) and is 1.5 m in Borehole SC-7. The till deposit consists of clayey silt containing trace to some sand and trace gravel

The measured SPT ‘N’ values within the clayey silt till deposit were 32 blows and 66 blows per 0.3 m of penetration, suggesting that the clayey silt till is of a hard consistency.

4.4.8 Silt to Sand to Sand and Gravel

Granular deposits comprised of silt to sand to sand and gravel were encountered underlying the till deposit or interlayered within the till deposit in Boreholes 12-6, SC-7 and BO-9. The thickness of the granular deposit ranges from 0.1 m to 17.1 m. Boreholes SC-7 and BO-9 were terminated within this deposit at depths of 40.1 m and 26.5 m (Elevation 180.6 m and 194.5 m).

The measured SPT ‘N’ values within the granular deposit range from 21 blows to 286 blows per 0.3 m of penetration, but are generally greater than 60 blows per 0.3 m of penetration. These SPT ‘N’ values indicate that the deposit has a compact to very dense, but generally very dense relative density.

The results of five grain size distribution tests performed on samples of the sandy silt to sand to sand and gravel are shown on Figure B12A and B12B in Appendix B. Atterberg limits testing carried out one sample of silt measured a liquid limit of 20 per cent, a plastic limit of 16 per cent and a plasticity index of 4 per cent. The result of the Atterberg limits test, which is plotted on Figure B13 in Appendix B, indicates that the material is a silt of slight plasticity.

4.4.9 Sand and Silt Till

A deposit of sand and silt till was encountered below the clayey silt to silty clay in Boreholes 12-4, 12-7, 12-9, and 29-1 to 29-8 and below sandy silt to silty sand in Borehole 12-6. The surface to the sand and silt till deposit was encountered at depths ranging between 14.9 m and 21.4 m below ground surface (Elevation 206.9 m and 198.3 m). Boreholes 12-4, 12-6, 12-7, 12-9, 29-5 and 29-6 were terminated within the sand and silt till at depths of 19.9 m to 23.5 m below ground surface (Elevation 205.6 m to 196.0 m) after penetrating 1.2 m to 5.1 m into the deposit.

The sand and silt till deposit typically contains trace to some clay and trace gravel. Cobbles and boulders were noted to be present within the till deposit inferred by the grinding of augers as they advanced through the layer.

The measured SPT ‘N’ values within the sand and silt till deposit range from 37 blows to 162 blows per 0.3 m of penetration, indicating a dense to very dense relative density.

The results of four grain size distribution tests performed on samples of the sand and silt till from the current investigation are shown on Figure B14 in Appendix B. The results of two grain size distribution tests performed on samples of from the previous investigation are shown on the borehole records in Appendix D. Atterberg limits testing carried out on three samples of the sand and silt till from the current investigation measured liquid limits between 13 per cent and 15 per cent, plastic limits between 11 per cent and 12 per cent, and plasticity indices between 3 per cent and 4 per cent. The results of the Atterberg limits testing, which are plotted on Figure B15 in Appendix B, indicate that the material is a silt of slight plasticity.

4.4.10 Clayey Silt Interlayers

Approximately 0.9 m to 6.1 m thick clayey silt interlayers were encountered within the sandy silt to sand and gravel deposit in Boreholes SC-7 and BO-9. Silt seams were encountered in Borehole SC-7. The base of these interlayers was encountered between Elevation 196.2 m and Elevation182.3 m.

The measured SPT ‘N’ values within the clayey silt interlayers range from 52 blows to 100 blows per 0.3 m of penetration, suggesting a hard consistency.

The results of two grain size distribution tests performed on samples of the clayey silt interlayers are shown on Figure B16 in Appendix B. Atterberg limits testing carried out on two samples of the clayey silt interlayers measured liquid limits of 18 per cent and 29 per cent, plastic limits of 10 per cent and 15 per cent, and plasticity indices of 8 per cent and 14 per cent. The results of the Atterberg limits testing are plotted on Figure B17 in Appendix B, and suggest that the material is a clayey silt of low plasticity. The natural water content measured on these same samples is approximately 12 per cent and 21 per cent.

4.4.11 Groundwater Conditions

The observed/recorded water levels in the open boreholes and/or casing during drilling operations, following completion of drilling and in the standpipe piezometer installed in Borehole 12-6 are shown on the Record of Borehole sheets are summarized as follows:

Borehole / Piezometer	Ground Surface Elevation (m)	Approximate Depth/Elev. at which Artesian Groundwater Conditions Encountered (m)	Depth to Groundwater Level (m)	Groundwater Level Elevation (m)	Date	Notes
12-3	225.0	-	2.3	222.7	May 28, 2012	Open Borehole
12-4	219.5	-	2.0	217.5	May 11, 2012	Open Borehole
12-5	223.5	-	2.9	220.2	May 29, 2012	Open Borehole
12-6	219.7	-	2.0 2.0	218.0 218.0	May 14, 2012 May 15, 2012	Open Borehole Piezometer
12-7	220.4	-	1.8	218.6	May 9, 2012	Open Borehole
12-8	224.1	-	4.4	219.7	May 30, 2012	Open Borehole
12-9	219.5	-	1.0	218.5	May 10, 2012	Open Borehole
12-10	222.0	-	0.1	221.9	May 30, 2012	Open Borehole
SC-5	221.1	15.2/205.9	4.2	216.9	November 15, 2012 (Completion of drilling)	Open Borehole
SC-7	220.7	15.8/205.0	1.5 ags*	222.2	November 7, 2012 (During casing removal)	Inside Casing
SC-8	220.5	-	5.5	215.0	November 7, 2012 (Completion of drilling)	Open Borehole
BO-9	221.0	25.9/195.1	1.0 ags*	222.0	November 18, 2011	Inside Casing

Notes: *ags = above ground surface

The water levels observed in the open boreholes on completion of drilling may not represent long-term stabilized groundwater levels. The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.

4.5 South Canal Berm – South Canal Bank Road Station 9+860 to Station 10+100

Boreholes 12-1, 12-2, 12-11 to 12-14, SC-3, SC-4 and SC-9 were advanced within or near the limits of the proposed berm to be located between the South Canal and South Canal Bank Road, at the locations shown on Drawing 5. The interpreted stratigraphic profile along the proposed berm is also shown on Drawing 5. The detailed soil and groundwater conditions encountered in the boreholes advanced for this investigation and the results of in situ and laboratory tests carried out on selected soil samples are provided in Appendix C. Boreholes 29-2 to 29-4 and 29-8 from the previous investigation, which were advanced by others, are also within or near the proposed berm limits and the Record of Borehole sheets and laboratory testing for these boreholes are included in Appendix D.

In general, the subsurface conditions at the site consist of surficial layers of topsoil, granular and cohesive fill and peat underlain by a clayey silt deposit. The clayey silt deposit is generally underlain by glacial till deposits with non-cohesive interlayers consisting of sandy silt to silty sand to sand and gravel.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.5.1 Topsoil and Asphalt

Approximately 200 mm of topsoil was encountered immediately below the existing ground surface in Boreholes 12-11, 12-13, SC-3 and SC-9. Boreholes 12-11 and SC-3 were advanced at the base of the east side of the existing embankment and Boreholes 12-13 and SC-9 were advanced on the west side.

4.5.2 Fill

Fill consisting of clayey silt and silty sand to sandy silt was encountered in some of the boreholes advanced for the realignment of South Canal Bank Road and is described in more detail below.

4.5.2.1 *Clayey Silt Fill*

A layer of clayey silt fill was encountered below the topsoil layers or at ground surface in Boreholes 12-11, 12-12, 12-14, SC-3 and 29-2 and below sand and silt to silty sand fill in Borehole SC-4. The elevation of the surface and base of the clayey silt fill deposit and the deposit thickness as encountered in the boreholes are summarized below.

Borehole No.	Depth to Surface (m)	Layer Surface Elevation (m)	Layer Thickness (m)	Layer Base Elevation (m)
12-11	0.2	219.3	3.5	215.8
12-12	0.0	219.0	3.7	215.3
12-14	0.0	219.2	0.8	218.4
SC-3	0.2	219.9	1.1	218.8
SC-4	1.5	219.3	0.6	218.7
29-2	0.0	223.9	5.6	218.3

The clayey silt fill layer contains varying amounts of sand and gravel and layers of silty sand were noted in Borehole 12-12. Trace quantities of organic material were also noted to be present within the fill layer in Boreholes 12-11, 12-12, 12-14, SC-3 and SC-4.

The measured SPT 'N' values within the clayey silt fill deposit range from 3 blows to 27 blows per 0.3 m of penetration, suggesting a soft to very stiff consistency.

The results of three grain size distribution tests performed on samples of the clayey silt fill from the current investigation are shown on Figure C1 in Appendix C.

Atterberg limits testing carried out on three samples of the clayey silt fill from the current investigation measured liquid limits ranging from 16 per cent to 26 per cent, plastic limits ranging from 10 per cent to 16 per cent and plasticity indices ranging from 6 per cent to 11 per cent. The test results, which are plotted on a plasticity chart on Figure C2 in Appendix C, indicate that the fill material is a clayey silt of low plasticity. Atterberg limits testing carried out on a sample of the clayey silt fill from the previous investigation is shown on the borehole record in Appendix D. The natural water content measured on samples from the current investigation ranges from about 10 per cent to 20 per cent.

4.5.2.2 *Sandy Silt to Silty Sand Fill*

Layers of sandy silt to silty sand fill were encountered at ground surface in Borehole SC-4 and below the clayey silt fill in Borehole SC-3 at a depth of 1.3 m below ground surface. The thickness of the sandy silt to silty sand fill ranges from 1.4 m to 1.5 m. The fill contains trace clay, trace to some gravel, organics and wood fragments.

The measured SPT 'N' values within the fill range from 6 blows to 27 blows per 0.3 m of penetration, indicating a loose to compact relative density.

4.5.3 Peat

Peat was encountered below the clayey silt fill in Borehole 12-14 and SC-4 and within the clayey silt in Borehole 12-13. The surface of the peat layer was encountered at depths ranging between 0.5 m and 2.1 m below ground surface (between Elevation 218.8 m and 218.4 m) and the peat is 0.1 m to 1.4 m thick. The peat is typically silty.

The measured SPT 'N' values within the peat range from 3 blows to 9 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

An organic content test performed on a sample of the peat showed 28 per cent organics.

4.5.4 Silt to Silty Sand (Upper Deposit)

An upper layer of silt to silty sand was encountered below the fill in Borehole 29-2, below the peat in Boreholes 12-14 and SC-4, below the topsoil in Borehole SC-9 and at ground surface in Boreholes 29-4 ad 29-8. The surface of the upper silt to silty sand was encountered at depths ranging between 0 m (ground surface) and 5.6 m below ground surface (Elevation 221.1 m to Elevation 217.0 m). The thickness of the upper silt to silty sand ranges from 0.4 m to 2.7 m.

The upper silt to silty sand layer typically contains trace to some clay and organics were noted to be present in Boreholes SC-4, 29-4 and 29-8.

The measured SPT ‘N’ values within the upper silt to silty sand range between 6 blows and 23 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The results of grain size distribution testing completed on three samples of the upper silt to silty sand from the current investigation are shown on Figure C3 in Appendix C. The results of grain size distribution tests performed on samples from the previous investigation are shown on the borehole records in Appendix D.

4.5.5 Clayey Silt (Upper Deposit)

Clayey silt was encountered in all boreholes advanced within the berm area. The clayey silt was encountered at depths between 0 m (ground surface) and 7.3 m below ground surface (between Elevation 215.3 m and 220.6 m) and the thickness of the clayey silt ranged from 4.3 m to 12.2 m.

The clayey silt deposits typically contain trace to some sand and seams/interlayers of silt to silty sand were noted to be present in Boreholes 12-13, SC-4 and SC-9. Trace quantities of organic material are present within the upper portions of the clayey silt deposits in Boreholes 12-1, 12-2, 12-12, 12-13, SC-9 and 29-4.

The measured SPT ‘N’ values within the clayey silt deposits range from 0 blows (weight of the SPT hammer advanced the sampler) to 31 blows per 0.3 m of penetration, but typically range from 1 blow to 15 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency. Vane shear tests performed within the clayey silt deposits range from 22 kPa to greater than 115 kPa (vane torque refusal), but typically range from approximately 20 kPa to 50 kPa, indicating a soft to firm consistency.

The results of six grain size distribution tests performed on samples of the clayey silt deposit from the current investigation are shown on Figure C4 in Appendix C. The results of three grain size distribution tests performed on samples from the previous investigation are shown on the borehole records in Appendix D.

Atterberg limits testing carried out on seventeen samples of the clayey silt from the current investigation measured liquid limits ranging from 16 to 34 per cent, plastic limits ranging from 10 to 17 per cent and plasticity indices ranging from 2 to 18 per cent. The test results, which are plotted on a plasticity chart on Figure C5A to C5C in Appendix C, indicate that the material is generally a clayey silt of low plasticity, with some samples classified as silt of slight plasticity. Atterberg limits testing carried out on samples from the previous investigation are shown on the borehole records in Appendix D.

The natural water content measured on samples from the current investigation ranges from about 13 per cent to 30 per cent. An organic content test performed on a sample of the upper portion of the clayey silt showed 4 per cent organics.

Laboratory consolidation tests were carried out on two thin-walled Shelby tube samples of the clayey silt deposit. The consolidation test results are presented on Figures C6 to C7 in Appendix C and are summarized in the following table.

Borehole/ Sample No.	Sample Depth/Elev. (m)	Unit Weight (kN/m^3)	σ_{vo}' (kPa)	σ_p' (kPa)	σ_p' - σ_{vo}' (kPa)	OCR	e_o	C_c	C_r	C_v* cm^2/s
12-14 / S7	6.3 / 212.9	20.6	56	296	240	5.3	0.65	0.16	0.020	1.5×10^{-3}
SC-3 / S1	5.6 / 214.5	20.7	50	280	230	5.6	0.64	0.13	0.025	3.5×10^{-3}

Notes: * for approximate stress range $20 \leq \sigma \leq 150$ kPa

where	σ_p'	Estimated preconsolidation stress	σ_{vo}'	Computed existing vertical effective stress
	C_c	Compression index	C_r	Recompression index
	e_o	Initial void ratio	OCR	Overconsolidation ratio
			C_v	Coefficient of consolidation (cm^2/s) in the normally consolidated range

4.5.6 Silt Interlayers

Silt interlayers, approximately 1.4 m and 1.6 m thick, were encountered within the clayey silt deposits in Boreholes 12-13 and SC-9. The interlayers typically contain some sand and trace to some clay. The measured SPT ‘N’ values within the silt interlayers range from 13 blows to 25 blows per 0.3 m of penetration, indicating a compact relative density.

Atterberg limits testing carried out on one (1) sample of the silt measured a liquid limits of 19 per cent, a plastic limit of 17 per cent and a plasticity index of 2 per cent. The results, which are plotted on Figure C8, indicate that the material is a silt of slight plasticity.

4.5.7 Clayey Silt Till

A 1.0 m to 9.2 m thick deposit of clayey silt till was encountered underlying the clayey silt in Boreholes 12-1, 12-2, 12-13, 12-14 and SC-9 and below silty sand in Borehole SC-3 at depths ranging from 8.7 m to 12.2 m below ground surface (Elevation 210.8 m to 207.0 m). Boreholes 12-1, 12-13 and 12-14 were terminated within this deposit after penetrating 1.7 m to 5.6 m into the deposit at depths ranging from 13.6 m to 14.3 m below ground surface (Elevation 205.4 m to 204.9 m).

The till deposit consists of clayey silt with sand to trace sand, containing trace gravel.

The measured SPT ‘N’ values within the clayey silt till deposit range from 7 blows per 0.3 m of penetration to 80 blows per 0.1 m of penetration, but typically range from 60 blows to 90 blows per 0.3 m of penetration. The SPT results suggest that the clayey silt till ranges from firm to hard in consistency, but is typically hard.

The results of six grain size distribution tests performed on samples of the clayey silt till are shown on Figure C9 in Appendix C.

Atterberg limits testing carried out on six samples of the clayey silt till from the current investigation measured liquid limits ranging from 15 per cent to 21 per cent, plastic limits ranging from 9 per cent to 12 per cent and plasticity indices ranging from 6 per cent to 9 per cent. The results of the Atterberg limits testing, which are plotted on Figure C10 in Appendix C, indicate that the material is a clayey silt of low plasticity. The natural water content measured on samples of the clayey silt till from the current investigation ranges from about 8 per cent to 15 per cent.

4.5.8 Silt to Sand and Gravel

Granular deposits comprised of silt to sand and gravel were encountered underlying the clayey silt and till deposits or interlayered within the till deposits in Boreholes 12-2, 12-11, 12-12, SC-3, SC-4 and SC-9. The thickness of the granular deposit / interlayers ranges from 0.2 m to 5.3 m. Boreholes 12-2, 12-11, 12-12, SC-3, SC-4 and SC-9 were terminated within the silt to sand and gravel at depths ranging from 10.7 m to 27.9 m below ground surface (Elevation 208.8 m to 192.9) after penetrating 0.9 m to 5.5 m into the granular layers.

The measured SPT ‘N’ values within the granular deposit range from 5 blows per 0.3 m of penetration to 100 blows per 0.08 m of penetration, indicating a loose to very dense relative density.

The results of seven (7) grain size distribution tests performed on samples of silt to sand are shown on Figure C11.

Atterberg limits testing carried out one sample of sandy silt to silt from the current investigation measured a liquid limit of 20 per cent, a plastic limit of 16 per cent and a plasticity index of 4 per cent. The result of the Atterberg limits testing, which is plotted on Figure C12, indicates that the material is a silt of slight plasticity.

4.5.9 Sand and Silt Till

A deposit of sand and silt till was encountered below the sandy silt in Borehole SC-4 and below the clayey silt in Boreholes 29-2 to 29-4 and 29-8 at depths ranging between 9.8 m and 14.9 m (Elevation 210.9 m and 206.0 m). Boreholes 29-2 to 29-4 and 29-8 were terminated within the sand and silt till deposit at depths ranging from 13.9 m to 20.3 m below ground surface (Elevation 206.7 m to 175.2 m) after penetrating 4.0 m to 5.4 m into the deposit. When fully penetrated in Borehole SC-4, the till deposit was 5.4 m thick. The sand and silt till deposit typically contains trace to some clay and trace gravel.

The measured SPT ‘N’ values within the sand and silt till deposit range from 70 blows per 0.3 m of penetration to 108 blows per 0.15 m of penetration, indicating a very dense relative density.

The results of one grain size distribution test performed on a sample from the current investigation are shown on Figure C13 in Appendix C. The results of two grain size distribution tests performed on samples from the previous investigation are shown on the borehole records in Appendix D.

Atterberg limits testing carried out on two samples of the sand and silt till from the current investigation measured liquid limits of 15 per cent and 16 per cent, plastic limits of 11 per cent and plasticity indices of 4 per cent and 5 per cent. The results of the Atterberg limits testing, which are plotted on Figure C14 in Appendix C, indicate that the material is a silt of slight plasticity.

4.5.10 Clayey Silt Interlayers

A 1.5 m thick interlayer of clayey silt was encountered in Borehole SC-4 at a depth of 25.5 m below ground surface (Elevation 195.3 m). The clayey silt interlayer contains trace sand and seams of silty sand.

A measured SPT ‘N’ value within the clayey silt interlayer was 84 blows per 0.3 m of penetration, suggesting a hard consistency.

4.5.11 Groundwater Conditions

The observed/recorded water levels in the open boreholes and/or casing during drilling operations and following completion of drilling are shown on the Record of Borehole sheets are summarized as follows:

Borehole / Piezometer	Ground Surface Elevation (m)	Approximate Depth/Elevation at which Artesian Groundwater Conditions Encountered (m)	Depth to Groundwater Level (m)	Groundwater Level Elevation (m)	Date	Notes
12-1	219.0	-	Coincident with canal surface	219.0	Jun 25, 2012	Drilled in canal
12-2	219.0	-	Coincident with canal surface	219.0	Jun 26, 2012	Drilled in canal
12-11	219.5	8.0/211.5	Not Recorded	Not Recorded		
12-12	219.0	-	0.4	218.6	May 15, 2012	Open borehole
12-13	219.3	-	6.6	212.7	May 10, 2012	Open borehole
12-14	219.2	-	Not Recorded	Not Recorded		
SC-3	220.1	11.7/208.4	3.6 ags*	223.7	May 25, 2012 (Completion of drilling)	Inside casing
SC-4	220.8	22.9/197.9	Not Recorded	Not Recorded	-	
SC-9	221.0	18.3/202.7	4.1 ags*	225.1	May 16, 2012 (Completion of drilling)	Inside casing

Notes: * ags = above ground surface

The water levels observed in the open boreholes on completion of drilling may not represent long-term stabilized groundwater levels. The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Ted Beadle and reviewed by Ms. Sandra McGaghran, P.Eng., a geotechnical engineer and Associate with Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Contact for Foundations and a Principal of Golder, provided quality control review of this report for conformance with the project Terms of Reference.

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PART B

FOUNDATION DESIGN REPORT
EMBANKMENT WIDENING AND RSS WALL CONSTRUCTION
HIGHWAY 400 WIDENING FROM NORTH OF KING ROAD TO NORTH OF SOUTH CANAL BRIDGES
REGIONAL MUNICIPALITY OF YORK
GWP 2025-13-00

6.0 FOUNDATION ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides discussion and recommendations regarding foundation engineering aspects for the high fill embankment widening, retaining wall and berm, as follows:

- Widening of the Highway 400 embankments south of the South Canal bridges, between approximately Station 24+650 and 24+800 SBL, and 24+650 and 24+840 NBL. These are shown as Areas 1 and 2, respectively, on the index plan on Figure 1.
- Widening of the Highway 400 embankments north of the South Canal bridges, between approximately Station 24+880 and 25+120 SBL, and 24+900 and 25+120 NBL. These are shown as Areas 3 and 4, respectively, on the index plan on Figure 1.
- Construction of a berm along the north side of the realigned South Canal, between approximately Station 9+860 and 10+150 (relative to South Canal Bank Road). The purpose of this berm is to separate South Canal Bank Road from the canal and minimize the potential for flooding under certain water level conditions.

The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this subsurface investigation, supplemented with data from a previous investigation performed by Department of Highways Ontario (DHO) in 1970. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible alternatives and to carry out the design of the embankment widening, retaining wall, and the new berm.

Where comments are made on construction, they are provided to highlight those aspects which could affect the design of the project. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Embankment Widening South of South Canal Bridges (Areas 1 and 2)

The proposed Highway 400 widening south of the South Canal bridges (SBL Station 24+650 to 24+800, and NBL Station 24+650 to 24+840 – Areas 1 and 2 as shown on Figure 1) will require widening by approximately 12 m to 20 m on the east and west sides of the northbound and southbound lanes. The design cross-sections indicate a design grade decreasing from about Elevation 232.5 m to 228 m in this area, and a maximum embankment height of approximately 9 m on the west side of Highway 400, and 7 m on the east side.

6.2.1 Removal of Peat/Organic Soils

It is recommended that all topsoil, peat/organic soil and existing surficial fill materials be stripped from the footprint of the proposed high fill embankment widening. The existing ground surface within the proposed embankment widening footprint slopes from approximately Elevation 230 m at the south limit of this area (Station 24+680) to approximately Elevation 220 m at the north extent (approximately Station 24+800 to 24+840 m) near the existing south abutment of the South Canal bridges. Based on the borehole results on the east and west sides of Highway 400, subexcavation of the peat/organic soil (together with fill that is present atop the peat/organic soil at some locations) will be required. The following subexcavation depths are recommended:

Area	Subexcavation Depth or Elevation
Area 1 – Westward widening 24+650 to 24+790 24+790 to 24+800	 To 1.7 m depth To Elevation 219.5 m
Area 2 – Eastward widening 24+650 to 24+840	 To 2.5 m depth

6.2.2 Global Stability

Slope stability analyses have been completed for the proposed embankment widening using the commercially available program Slide from Rocscience, to assess the minimum Factor of Safety for the proposed fill embankment widening. A target minimum factor of safety of 1.3 is normally used in the design of slopes under static conditions. Under earthquake conditions, the stability of slopes is assessed using conventional pseudo-static methods of slope stability analysis under the earthquake-induced peak ground acceleration; a calculated factor of safety of 1.0 is typically used for global stability under seismic conditions. These minimum factors of safety are considered appropriate for the proposed Highway 400 embankment widening south of the South Canal bridges, considering the design requirements and the available field and laboratory testing data.

The following parameters have been used in the slope stability analyses, based on field and laboratory test data as well as accepted correlations (Bowles, 1984 and Kulhawy and Mayne, 1990):

Soil Deposit	Short-term (Undrained) Analysis			Long-term (Drained) Analysis		
	Bulk Unit Weight (kN/m^3)	Effective Friction Angle Φ’	Undrained Shear Strength (kPa)	Unit Weight (kN/m^3)	Effective Friction Angle Φ’	Cohesion (kPa)
Existing embankment	19	32°	-	19	32°	0
New embankment fill	21	34°	-	21	34°	0
Compact sandy silt to silty sand	18	28°	-	18	28°	0
Stiff to hard clayey silt till	21	-	200	21	32°	0
Very dense sand and silt till	21	34°	-	21	34°	0
Firm to very stiff clayey silt	19	-	75	19	30°	0
Very dense sand	19	34°	-	19	34°	0

The static global stability analysis results indicate that the widened, 7 m to 9 m high embankments in Areas 1 and 2 will have a factor of safety of at least 1.3 in both short-term and long-term conditions. These results are based on side slopes oriented no steeper than 2 horizontal to 1 vertical (2H:1V), and assume appropriate subgrade preparation including stripping of peat/organic soils as outlined above, and appropriate compaction of the engineered fill materials for the embankment widening. Example static global stability results for both short-term (undrained) and long-term (drained) conditions for the critical embankment sections on the west and east sides of Highway 400 (Areas 1 and 2, respectively) are provided on Figure 2 to 5.

The pseudo-static seismic slope stability analyses for a 2H:1V slope configuration in Areas 1 and 2 will have a factor of safety greater than 1.0 against deep-seated slope instability, using a peak ground acceleration of 0.06g. Some shallow sloughing could occur on the slopes during seismic events. This sloughing would not, however, impair the use of the highway, and would mainly be a maintenance issue. The potential for sloughing following seismic events could be reduced by providing well-vegetated slopes, per OPSS 804 *(Seed and Cover)*.

6.2.3 Embankment Settlement

Based on the design cross-sections, the proposed embankment widening south of South Canal will be between 15 m and 20 m on the west side (Area 1) and between 12 m and 15 m on the east side (Area 2). This will require placement of a maximum vertical fill thickness of approximately 9 m in Area 1, and 7 m in Area 2.

Settlement analyses for the soils below the widened embankments were carried out using both hand calculations and the commercially available computer program *Settle-3D* from Rocscience, using estimated elastic deformation moduli and consolidation settlement parameters as given in the table below, based on correlations with the SPT “N” values, shear vanes and engineering judgement from experience with similar soils in this region of Ontario (Bowles, 1984; Kulhawy and Mayne, 1990; Peck et al., 1974). The settlement analyses assume that all existing fill and peat/organic soils have been removed from the embankment footprint prior to placing the new embankment fill. The subsurface conditions between the west side of Highway 400 and east side are slightly different and the following provides the consolidation settlement parameters used for the embankment widening on the east side and west side of Highway 400.

Area 1 – West Side of Highway 400

Soil Deposit	Bulk Unit Weight (kN/m^3)	Elastic Modulus (MPa)	m_v (kPa^{-1})
Embankment fill (existing and new)	21	–	--
Compact to dense sand and silt	18	12	--
Firm to very stiff clayey silt	19	–	1.3×10^{-4}
Stiff to hard clayey silt till / compact to very dense sand and silt till	21	40	--

Area 2 – East Side of Highway 400

Soil Deposit	Bulk Unit Weight (kN/m^3)	Elastic Modulus (MPa)	m_v (kPa^{-1})
Embankment fill (existing and new)	21	–	--
Compact to dense sand and silt	18	12	--
Firm to very stiff clayey silt	19	–	3.8×10^{-4}
Stiff to hard clayey silt till / very dense sand and silt till	21	35	--

Based on the settlement analyses, the total settlement of the soils under the additional 9 m of fill associated with the west embankment widening (Area 1) is estimated to be approximately 65 mm, while that under the additional 7 m of fill associated with the east embankment widening (Area 2) is estimated to be approximately 50 mm. As noted above, this analysis assumes that the peat has been removed from below the footprint of the embankment, as recommended in Section 6.2.1.

On the west side of Highway 400 (Area 1), the total settlement represents both elastic compression of the compact to dense sand and silt and the till deposit, as well as some consolidation settlement associated with the firm portions of the clayey silt deposit. It has been estimated that the time to complete ninety per cent of the primary consolidation settlement for Area 1 will be approximately 2.5 months following placement of the fill for the embankment widening; after that time, less than approximately 5 mm to 10 mm of the primary consolidation will remain.

On the east side of Highway 400 (Area 2), the settlement may be considered to be essentially elastic as it will be completed relatively quickly following completion of the fill placement for the embankment widening. The firm portions of the clayey silt deposit were modelled using consolidation parameters, and it has been estimated that the time to complete 90 per cent of the settlement for the eastward widening will be less than two weeks following placement of the fill for the widening.

Based on the construction staging, it is understood that there is time in the construction schedule to allow for preloading of these widening areas to allow the majority of the settlement to occur prior to paving the widened portion of the embankments. An operational constraint has been developed to address preloading in these areas (see Appendix E) for inclusion in the Contract Documents.

The above estimates do not include compression of the fill itself, which would occur during and after the construction of the embankment depending on the type of materials used. The magnitude of fill compression may range from 0.5 to 1 per cent of the height of the embankment, assuming approximately 98 per cent compaction of the embankment fill is achieved, relative to the material’s standard Proctor maximum dry density. In the case where granular fill is used for embankment construction, settlement of the fill itself is expected to occur essentially during embankment construction, whereas non-granular earth fill materials are expected to exhibit some additional settlement over time.

6.3 Embankment Widening North of South Canal Bridges (Areas 3 and 4)

The proposed Highway 400 widening north of the South Canal bridges (SBL Station 24+880 to 25+120, and NBL Station 24+900 to 25+120 – Areas 3 and 4 on Figure 1) will require a widening of up to approximately 12 m on the east and west sides of the northbound and southbound lanes. The design cross-sections indicate a design grade decreasing from a maximum embankment height of approximately 6.5 m just north of the north approach of the South Canal bridges (Elevation 227 m) to approximately 3.5 m (Elevation 223.5 m) at Station 25+120 on both the east and west sides. Existing local roads are located in close proximity to the west and east sides of the Highway 400 embankment in this area – Davis Road on the west, and Wist Road on the east. It is understood that MTO prefers to minimize relocation of the local roads in order to minimize impacts on the commercial and agricultural properties adjacent to Wist and Davis Roads.

Approximately 2 m to 3 m of peat was removed during the initial construction of the Highway 400 embankments through Holland Marsh; based on the results of the current borehole investigation, some peat/organic soils are still present within the proposed embankment widening footprint, typically below a thin layer of fill. Subexcavation of this existing peat/organic soil is required for all embankment widening options because of global stability and long-term performance issues associated with organic soils. This subexcavation of the existing peat/organic soil will extend approximately 2 m to 3 m below the toe of the existing Highway 400 embankment.

An extensive deposit of clayey silt to silty clay is present below the peat/organic soils in Areas 3 and 4. The upper 1.5 m to 2 m of this deposit has a very soft to soft consistency in many of the boreholes, and the presence of this “weaker” material adversely impacts the global stability of the proposed embankment widening or retaining wall construction. In order to achieve the minimum acceptable factor of safety for global stability, it will be necessary to adopt one of the following measures:

- Deeper subexcavation of the very soft to soft clayey soils, to depths of 4.4 m to 5 m on the Davis Road (Area 3) and Wist Road (Area 4) sides, respectively, to improve the strength of this layer;
- The use of lightweight fill materials for construction of the embankment widening and/or retaining wall, to minimize the weight and “driving force” of the widened embankment; and/or
- The use of in situ ground improvement techniques to treat the soil under the widened area.

Area 3 – Westward Widening (Davis Road Side)

The following options have been considered for the widening on the west side of Highway 400:

- A conventional 2 horizontal to 1 vertical (2H:1V) embankment side slope; geometrically, this would result in a requirement for some minor westward realignment of Davis Road and an existing berm along the west side of Davis Road.
- A 1.5H:1V reinforced slope, which geometrically would result in no impact to Davis Road or the adjacent berm.
- Steeper rock fill embankments (1.25H:1V), reinforced slopes (1H:1V or steeper), or the use of a vertical retaining wall, while technically feasible, would be more expensive given the subexcavation, stability and settlement mitigation measures that would be required (as discussed in subsequent sections of this report). Therefore, given that the above two options were considered appropriate with respect to geometric constraints and minimal property impacts, a decision was taken not to consider such steeper options for detail design.

As discussed in Section 6.3.1, in order achieve the required minimum factor of safety for global stability of the westward widening, subexcavation of the existing peat and organic soils is required below the widening footprint. Even with this subexcavation and backfilling, the use of conventional earth fill, granular fill or chip stone fill materials for the widening would produce a factor of safety of less than 1.3 against global instability of the widened embankment (see Section 6.3.2). Lighter weight fill materials, or other stability mitigation measures such as additional subexcavation of softer clayey soils below the peat/organic soils, or ground improvement below the embankment widening area, would be required in order to achieve a minimum factor of safety of 1.3 (see Sections 6.3.2.1 and 6.3.2.3). The use of lightweight fill materials also serves to mitigate settlement in the underlying, compressible clayey soil deposit under the embankment widening area (see Section 6.3.3). The advantages, disadvantages, risks, benefits and approximate costs for the key options/mitigation measures associated with the westward widening in Area 3 are also presented in summary form in Table 1 following the text of this report.

Based on Golder's analyses, discussions with the design team and contractors, and comparisons of options as presented in the above-noted sections and Table 1, the preferred option from a foundations perspective is to construct the westward embankment widening (Area 3) with 2H:1V side slopes, using lightweight slag fill in order to achieve the minimum required factor of safety for global stability.

Area 4 – Eastward Widening (Wist Road Side)

Between the existing alignment of Wist Road and the proposed toe of the widened Highway 400 embankment there is less space in comparison to the west (Davis Road) side. Various geometric options were considered early in the detail design, with a goal of maintaining the existing alignment of Wist Road and avoiding property impacts to the adjacent commercial agricultural facility, as follows:

Geometric Option	Comments
Conventional 2H:1V slope	Geometrically would result in a requirement to realign Wist Road and impact the adjacent commercial development.
Steeper reinforced earth slope	In order to maintain the existing alignment of Wist Road, the reinforced earth slope would need to be constructed at 0.58H:1V. While technically feasible, this option would require protection systems for subexcavation of peat and organic soils, and stability and settlement mitigation measures, as discussed further in subsequent sections of the report.
A 2 m high retaining wall with 1.5H:1V reinforced earth slope above	Would not allow current alignment of Wist Road to be maintained over full length. Therefore, geometrically undesirable.
An approximately 4 m high retaining wall with 1.5H:1V reinforced earth slope above	Allows for current alignment of Wist Road to be maintained. Geometrically acceptable. Pile-supported concrete retaining walls and retained soil system (RSS) walls were considered based on presence of compressible clayey soils under the site, and two-stage RSS walls were selected as preferred retaining wall approach from a cost perspective. Would require protection systems for subexcavation of peat and organic soils, and stability and settlement mitigation measures, as discussed further in subsequent sections of the report.
A "full-height" retaining wall	Allows for current alignment of Wist Road to be maintained. Geometrically acceptable. Pile-supported concrete retaining walls and retained soil system (RSS) walls were considered based on presence of compressible clayey soils under the site, and two-stage RSS walls were selected as preferred retaining wall approach from a cost perspective. Would require protection systems for subexcavation of peat and organic soils, and stability and settlement mitigation measures, as discussed further in subsequent sections of the report.

Ultimately, from a geometric perspective, the design team selected a retaining wall with a maximum height of approximately 5 m as the preferred design solution.

As discussed in Section 6.3.1, in order achieve the required minimum factor of safety for global stability of the westward widening, subexcavation of the existing peat and organic soils is required below the widening footprint. Deeper subexcavation of the upper 1.5 m to 2 m, very soft to soft zone of the clayey deposit would require excavation to a depth of approximately 5 m, would also be needed in order to achieve the necessary factor of safety for global stability. However, as presented in Section 6.3.2.2, such deep subexcavation adjacent to the Highway 400 embankment is considered to present a higher risk during construction. Ground improvement (such as soil mixing and aggregate piers – see Section 6.3.2.4) would carry a lower risk relative to deep subexcavation, but a relatively high cost. Therefore, geotechnical analyses and assessments focused on the use of lightweight fill materials, ranging (from heaviest to lightest) from chip stone, to lightweight and ultra-lightweight slag fill, to cellular concrete, to expanded polystyrene (EPS) foam (see Section 6.3.2.3). The use of lightweight fill materials also serves to mitigate settlement in the underlying compressible clayey soil deposit. The advantages, disadvantages, risks, benefits and approximate costs for the key options/mitigation measures associated with the eastward widening in Area 4 are also presented in summary form in Table 2 following the text of this report.

Based on Golder's analyses, discussions with the design team and contractors, and comparisons of options as presented in the above-noted sections and Table 2, the preferred option from a foundations perspective is to construct the eastward embankment widening (Area 4) as a two-stage retained soil system wall, using ultra-lightweight slag fill in order to achieve the minimum required factor of safety for global stability.

6.3.1 Subexcavation of Peat/Organic Soils

As noted above, approximately 2 m to 3 m of peat was removed during initial construction of the Highway 400 embankments through Holland Marsh; some peat/organic soils are still present within the proposed embankment widening footprints in Areas 3 and 4, typically below a thin layer of fill. Subexcavation of this existing peat/organic soil is required due to global stability and long-term performance issues associated with organic soils. This subexcavation of the existing peat/organic soil will extend approximately 2 m to 3 m below the toe of the existing Highway 400 embankment. The following table summarizes the required depth of subexcavation, including those areas north of the Areas 3 and 4 (based on the results from the pavement borehole data).

Area	Subexcavation Depth or Elevation
Area 3 – Westward widening	
Station 24+880 to 25+100	To 2.2 m depth
Station 25+100 to 25+300	To 2.1 m depth
Station 25+300 to 25+500	To 1.8 m depth
Station 25+500 to 25+700	To 2.1 m depth
Station 25+700 to north limit	To 2.5 m depth
Area 4 – Eastward widening	
Station 24+900 to 25+150	To Elevation 217.0 m
Station 25+150 to 25+300	To 2.3 m depth
Station 25+300 to 25+600	To 2.1 m depth
Station 25+600 to north limit	To 1.8 m depth

Staged subexcavation, in strips of limited width, will be required to maintain the stability of the temporary subexcavation in Areas 3 and 4, to protect the Highway 400 embankment as well as Davis and Wist Roads. It is envisaged that this subexcavation will be completed in "wet conditions" (i.e., without dewatering), as follows:

- Removal of the peat/organic soils and the overlying fill materials within the approach embankment or wall footprint is to be carried out in short "strip" sections perpendicular to the Highway 400 and local road alignments, with the base of the excavation (as measured parallel to the toe of the Highway 400 embankment or local road) not wider than 3 m.

- Temporary excavation side slopes or back slopes through the peat/organic soils and overlying fill materials shall be no steeper than 1 horizontal to 1 vertical (1H:1V).
- Excavation and backfilling operations are to be carried out simultaneously in a manner that the excavation is not left open for more than the 3 m “strip” width at any given time.

An Operational Constraint is provided in Appendix E to address this requirement, for inclusion in the Contract Documents. The subexcavation areas should be backfilled with Granular B Type II, which will minimize segregation of the soil particles during placement assuming wet conditions in the strip excavations.

6.3.2 Global Stability

Slope stability analyses have been completed for the proposed embankment widening and retaining wall using the commercially available program Slide from Rocscience, to assess the minimum Factor of Safety for the proposed fill embankment widening. Target minimum factors of safety of 1.3 and 1.5 are normally used in the design of slopes and walls, respectively, under static conditions. Under earthquake conditions, the stability of slopes or retaining structures is assessed using conventional pseudo-static methods of slope stability analysis under the earthquake-induced peak ground acceleration; a calculated factor of safety of 1.0 is typically used for global stability of embankments under seismic conditions. These minimum factors of safety are considered appropriate for the proposed Highway 400 embankment widening and retaining wall north of the South Canal bridges, considering the design requirements and the available field and laboratory testing data.

The table below summarizes the soil parameters that have been used in the stability analyses for Areas 3 and 4. The undrained shear strengths used in the analyses, as summarized in the table below, are based on the design shear strength profile provided on Figure 6. The soil parameters below are based on field and laboratory test data as well as accepted correlations (Bowles, 1984 and Kulhawy and Mayne, 1990). Figure 6 plots the corrected undrained shear strength (based on Bjerrum’s correction method) from in situ vane testing as well as shear strengths calculated from the oedometer test results based on the formula $s_u = 0.22 \times \sigma_p'$ (in kPa).

Soil Deposit	Short-term (Undrained) Analysis			Long-term (Drained) Analysis		
	Bulk Unit Weight (kN/m^3)	**Effective Friction Angle Φ’**	**Undrained Shear Strength (kPa)**	**Unit Weight (kN/m^3)**	**Effective Friction Angle Φ’**	**Cohesion (kPa)**
Existing embankment fill	21	30°	-	21	30°	-
New embankment fill	19	34°	-	19	34°	-
Replacement fill under slope (above water table)	20	28°	-	20	28°	-
Replacement fill under slope (below water table)	19	32°	-	19	32°	-
Peat	12	27°	-	12	27°	1
Soft to firm clayey silt	19	0°	20 - 45	19	30°	0
Loose to Compact silt to silty	20	30°	-	20	30°	0

Soil Deposit	Short-term (Undrained) Analysis			Long-term (Drained) Analysis		
	Bulk Unit Weight (kN/m^3)	Effective Friction Angle Φ’	Undrained Shear Strength (kPa)	Unit Weight (kN/m^3)	Effective Friction Angle Φ’	Cohesion (kPa)
sand						
Firm to stiff clayey silt	19	-	45	19	30°	0
Soft to firm clayey silt	19	-	20 – 40	19	30°	0
Dense to very dense sand and silt till	21	34°	-	21	34°	0

6.3.2.1 *Summary of Results and Overview of Stability Mitigation Alternatives*

The following points summarize the results of the global stability analyses for a 2H:1V embankment in Area 3 (westward widening – Davis Road side), and for an RSS wall in Area 4 (eastward widening – Wist Road side):

- For the portions of the embankment with a height less than 4.2 m, a factor of safety of greater than 1.3 is obtained, provided that the existing peat/organic soils are subexcavated within the footprint of the widened embankment (per Section 6.3.1). No other mitigation measures (such as deeper subexcavation, use of lightweight fill materials or ground improvement) are required to satisfy stability requirements. However, such mitigation measures will be required to address settlement, as discussed further in Section 6.3.3. Figures 7 and 8, following the text of this report, present global stability results for maximum 4 m high embankments under short-term and long-term conditions, respectively.

- For portions of the embankment widening greater than 4.2 m in height, a factor of safety of less than 1.3 is obtained if only subexcavation of the existing peat/organic soils is carried out.

- The implementation of one or more stability mitigation measures is required for the embankment widening and RSS wall construction in Areas 3 and 4, respectively, in order to achieve a factor of safety of greater than 1.3 (for slopes) or 1.5 (for walls), as follows:

    - Subexcavation to a depth of 4.4 m below the ground surface at the existing toe of the Highway 400 embankment in Area 3, and to a depth of 5 m in Area 4 (see Section 6.3.2.2). The requirements for protection systems in this application will be more significant than for subexcavation of the peat/organic soils only, owing to the greater depth of excavation. Operational constraints will apply to the subexcavation works to maintain stability of the existing Highway 400 embankment and local road, even with the use of protection systems.

    - Use of lightweight fill materials to lower the “driving force” (see Section 6.3.2.3). ¼-inch chip stone is not sufficiently light to achieve a factor of safety of 1.3 for the widening in Area 3 or 4. The optimum lightweight material to achieve a factor of safety of greater than 1.3 for the embankment widening in Area 3 is lightweight slag fill, while that for the RSS wall construction in Area 4 is ultra-lightweight slag fill. Lighter materials, including cellular concrete and EPS, will result in factors of safety that are greater than 1.3 as well, but at increased cost relative to lightweight or ultra-lightweight slag fill.

  - Ground improvement (see Section 6.3.2.4). This could consist of deep soil mixing, in which holes are augered in a grid pattern and cement is mixed with the existing soil within the augered hole to create stiffer columns. The soil mixing would need to extend at least to a depth of 4.4 m and 5 m below ground surface adjacent to Davis Road and Wist Road, respectively to achieve a Factor of Safety greater than 1.3 for global stability. Alternatively, aggregate pier foundations may be used, consisting of augered holes filled with lifts of aggregate that are each compacted by vertical ramming, building a highly compacted stone column in a grid pattern. In either case, in situ ground improvement would need to be completed following subexcavation and replacement of the existing peat/organic soils.

- As presented in the following sections and based on the comparison of advantages, disadvantages, risks, benefits and relative costs as outline above and in Tables 1 and 2:

  - **The use of lightweight slag fill is preferred from a foundations perspective for construction of the 2H:1V embankment widening in Area 3.** Figure 9, following the text of this report, presents the global stability results for an embankment that is approximately 5.5 m in height and constructed of lightweight slag fill. This figure demonstrates that the factor of safety in the short-term condition is 1.29; this factor of safety will improve in the long-term condition.

  - **The use of ultra-lightweight slag fill is preferred from a foundations perspective for construction of the RSS wall in Area 4.** Figure 10, following the text of this report, presents the global stability results for an RSS wall that is approximately 5.5 m in height and constructed of ultra-lightweight slag fill. This figure demonstrates that the factor of safety in the short-term condition is 1.33; this factor of safety will improve in the long-term condition to greater than 1.5.

- The pseudo-static seismic slope stability analyses for a 2H:1V slope configuration in Area 3 will have a factor of safety greater than 1.0 against deep-seated slope instability, using a peak ground acceleration of 0.06g. Some shallow sloughing could occur on the slopes in Area 3 during seismic events. This sloughing would not, however, impair the use of the highway, and would mainly be a maintenance issue. The potential for sloughing following seismic events could be reduced by providing well-vegetated slopes, per OPSS 804 *(Seed and Cover)*.

6.3.2.2 *Stability Mitigation – Subexcavation of Soft Clayey Silt*

Based on the borehole results, a zone of soft to very soft clayey soil is frequently present in the upper 1.5 m to 2 m of the deposit immediately underlying the peat/organic soils. Removal of this material, extending to a total depth of about 4.4 m in Area 3 (west side – Davis Road) and about 5 m in Area 4 (east side – Wist Road), would improve the factor of safety of the embankment widening or RSS wall construction to greater than 1.3 in short-term conditions. In order to achieve this minimum factor of safety:

- In Area 3, the full 4.4 m depth of subexcavation would need to extend from 1 m behind the existing Highway 400 embankment toe, to the toe of the widened embankment.

- In Area 4, the full depth 5 m depth of subexcavation would need to extend from 2.5 m in front (east) of the face of the RSS wall, to the back edge of the reinforcing strips (which will vary depending on the height of the wall); this will require cutting into the existing Highway 400 side slope.

The deep excavations to remove the very soft to soft clayey soils would require 6 m to 7 m high protection system along Highway 400, based on cutting into the existing embankment toe. Based on discussions with shoring contractors, it is recommended that an operational constraint be applied to limit the subexcavation to strip widths of 3 m in order to maintain the stability of the protection system, even with the inclusion of temporary anchors to assist in the limiting the lateral deformation and improving the stability of the protection system. Detail design of the protection system will be required by the Contractor, but feedback from shoring contractors suggests that likely two rows of low-capacity, temporary anchors will be needed for this option with a 4.4 m to 5 m deep subexcavation.

The subexcavation would need to be backfilled with Granular B Type II for the full depth – not just below the water table – due to the speed with which the strip excavation and backfill operation must proceed. The contractor will likely not be able to place and compact earth fill in layers immediately above the water table, and therefore it is considered that Granular B Type II will ultimately provide a better-performing base than uncompacted earth fills.

The estimated costs associated with this option are presented in Tables 1 and 2. It is noted that additional costs will apply for wasted material (i.e., the Granular B Type II lost at the interface between adjacent strips) would also apply but have not been included in the cost estimates in Tables 1 and 2.

Based on the risks associated with this significant depth of excavation adjacent to Highway 400, and the costs associated with the provision of an anchored protection system to maintain the factor of safety during subexcavation works, this stability mitigation option is not recommended.

6.3.2.3 *Stability Mitigation – Lightweight Fill Materials*

Lightweight fill materials can be used as an alternative to conventional earth or granular fill materials (which have a bulk unit weight on the order of 22 kN/m^3 and 20-21 kN/m^3, respectively). From heaviest to lightest, the following materials have been considered:

Fill Option	Approx. Unit Wt. (kN/m^3)	Comments
Earth Fill or Granular A	20-21	Conventional fill materials
¼-inch chip stone	16-17	More specialized material.
Lightweight slag (Litex 4449)	15	MTO has good experience and performance with slag fill in RSS applications. There is some potential for corrosion of the metal reinforcing strips, based on a case study, and thicker metal strips are recommended to mitigate this. An amendment to the Standard Special Provision (SSP) for RSS walls has been prepared to incorporate this requirement.

Combined Granular A and EPS	11-15	Although conceptually feasible, a “sandwich” construction with alternating layers of granular and EPS has not been used on an MTO 400-series highway. As an alternative to alternating thin layers of granular and EPS, it may be possible to use a zone of EPS at the top of the wall to reduce the overall weight.
Ultra-lightweight slag (Litex 4443)	11	As for Litex 4449, this application is on MTO’s DSM list. The same comments apply with respect to the potential for corrosion of the metal reinforcing strips. An amendment to the Standard Special Provision (SSP) for RSS walls has been prepared to incorporate this requirement.
Cellular concrete	5	Note that the use of cellular concrete in a structural application is not on MTO’s DSM list, and a review of this for MTO is ongoing related to the Windsor-Essex Parkway project.
EPS (for embankment widening in Area 3)	1	Significant cost premium. This material is not required to achieve minimum factor of safety for global stability in Area 3.

Golder completed stability analyses to identify the most cost-effective lightweight fill material in order to achieve a minimum factor of safety of 1.3 against global instability in short-term conditions. As noted above, lightweight slag fill (approximately 14 kN/m^3) is required for construction of the westward embankment widening in Area 3, and ultra-lightweight slag fill (approximately 11 kN/m^3) is required for construction of the eastward embankment widening/RSS wall in Area 4. The results of global stability analyses for the short-term conditions in these areas and applications are shown on Figures 9 and 10, respectively.

Where lightweight slag fill / lightweight cellular concrete is adopted, it is recommended that an NSSP be included in the Contract Documents to address the supply, placement and compaction of the lightweight fill. This aspect is discussed further in Section 6.6.4, and an NSSP is provided in Appendix E.

6.3.2.4 *Stability Mitigation – In Situ Ground Improvement*

As an alternative to subexcavation of the soft clayey soils to a depth of about 5 m or the use of lightweight fill materials, the use of deep soil mixing or aggregate piers could be considered to improve the performance of the compressible and soft soils. Both are in situ improvement techniques that involve improving columns of the ground in a grid pattern and neither requires construction dewatering. With both the aggregate pier and deep soil mixing options, the existing peat/organic soil must be subexcavated prior to implementation of the in situ ground improvement technique.

Assuming the use of conventional earth or granular fill for the embankment widening or RSS wall construction, the in situ ground improvement would need to extend through the soft clayey zone, to at least 212 m, in order to achieve a factor of safety of greater than 1.3 in short-term conditions. The results of global stability analyses demonstrating the approximate vertical extent for ground improvement to achieve this factor of safety are presented on Figure 11 for Area 3 (westward embankment widening) and Figure 12 for Area 4 (eastward embankment widening and RSS wall construction).

The costs associated with ground improvement techniques are presented in Tables 1 and 2 following the text of this report for Areas 3 and 4, respectively. As this option would still require subexcavation of the peat/organic soils, in conjunction with temporary protection systems, this option has been estimated to have the highest cost. From an advantage/disadvantage, risk/benefit and cost perspective, it is not as desirable as the use of lightweight fill materials for construction of the embankment widening and RSS wall on this project.

6.3.3 Embankment Settlement

Based on the design cross-sections, the proposed embankment widening in Areas 3 and 4 will be up to approximately 12 m (horizontal distance between existing and proposed crest), which will require placement of a maximum vertical fill thickness of new fill material of up to approximately 6.5 m at its highest, immediately north of the north abutments for the new South Canal bridges.

Settlement analyses for the soils below the widened embankments were carried out using both hand calculations and the commercially available computer program *Settle-3D* from Rocscience, using estimated elastic deformation moduli and consolidation settlement parameters as given in the table below, based on consolidation test results as well as correlations with the SPT “N” values, shear vanes and engineering judgement from experience with similar soils in this region of Ontario (Bowles, 1984; Kulhawy and Mayne, 1990; Peck et al., 1974). For the purpose of the settlement analyses it has been assumed that all existing asphalt, fill and peat/organic soils will be removed from the embankment footprint prior to placing the new embankment fill.

Soil Deposit	**Bulk Unit Weight (kN/m^3)**	**Elastic Modulus (MPa)**	**P_c' (kPa)**	**e_o**	**C_c**	**C_r**
Embankment fill (existing and new)	21	--	–	–	–	–
Very soft to soft clayey silt	19	20	50	0.64	0.16	0.025
Loose to Compact silt to silty sand	20	15	-	-	-	-
Soft to firm clayey silt	19	20	100 - 175	0.64	0.16	0.025
Stiff clayey silt	19	25				
Dense to very dense sand and silt till	21	50 - 75	–	–	–	–

6.3.3.1 *Primary Consolidation Settlement (No Settlement Mitigation Measures)*

Based on the settlement analyses, the primary consolidation settlement of the soils under the additional 6.5 m of fill associated with the west and east widening of the existing Highway 400 embankment is estimated to be up to approximately 200 mm in the highest embankment widening areas, north of the north abutments for the new South Canal bridges, decreasing to approximately 150 mm near Station 25+120. Per Section 6.3.1, these settlement estimates assume that the existing peat/organic soils are subexcavated from below the footprint of the widening areas.

It has been estimated that the time to complete 90 per cent of the primary consolidation settlement will be approximately nine to twelve months following placement of the fill for the embankment widening. It is estimated that less than 25 mm of primary consolidation will remain after this time. The predicted post-construction settlement due to the embankment widening construction can be mitigated or reduced with preloading, and/or the use of lightweight fill; these alternatives are further discussed in Section 6.3.3.3 to 6.3.3.7.

The above estimates do not include compression of the fill itself, which would occur during and after the construction of the embankment depending on the type of materials used. The magnitude of fill compression may range from 0.5 to 1 per cent of the height of the embankment, assuming approximately 98 per cent compaction of the embankment fill is achieved, relative to the material's standard Proctor maximum dry density. In the case where granular fill is used for embankment construction, settlement of the fill itself is expected to occur essentially during embankment construction, whereas non-granular earth fill materials are expected to exhibit some additional settlement over time.

6.3.3.2 Secondary (Creep) Settlement

In addition to primary consolidation within the clayey deposit at this site, secondary compression will also occur. Secondary compression is referred to as creep settlement and occurs over a long period of time, after substantial dissipation of excess pore pressure under a constant stress.

The magnitude of creep settlement following construction will depend on the method of construction/settlement mitigation adopted and the actual time required to achieve the majority of the primary consolidation. If preloading measures are implemented to achieve the majority of the primary consolidation settlement in advance of completion of the paving, it is estimated that for an RSS wall or earth embankment constructed using granular fill material up to about 40 mm of creep settlement could occur over a 10-year period following completion of construction.

6.3.3.3 Settlement Mitigation Options

The predicted post-construction settlement due to the embankment widening/RSS wall can be reduced using the following mitigation options (similar to the stability mitigation options):

- Deeper sub-excavation of soft to firm clayey silt soils;
- Preloading of the widened embankment areas;
- Use of lightweight fill such as slag, expanded polystyrene (EPS) or light-weight cellular concrete for construction of the widened portions of the embankment;
- Use of wick drains (in conjunction with preloading); or
- A combination of these measures.

In addition to the above, incorporation of a two-stage retained soil system wall is recommended to accommodate the estimated settlements in Area 4. With this type of wall, the reinforced soil mass is constructed with a wire facing and permitted to settle (effectively acting as a preload), after which the permanent facing panels are affixed, to maintain the aesthetic appearance of the facing panels.

6.3.3.4 Settlement Mitigation – Deeper Subexcavation of Soft to Firm Clayey Soils

This approach would involve subexcavation of approximately 1.5 m to 2 m of softer clayey soils, extending to a total depth of approximately 4.4 m and 5 m in Areas 3 and 4, respectively. As discussed in Section 6.3.2.2, based on the risks associated with this significant depth of excavation adjacent to Highway 400, and the costs associated with the provision of an anchored protection system to maintain the factor of safety during subexcavation works, this mitigation option is not recommended and it has not been considered further in this report.

6.3.3.5 *Settlement Mitigation – Preloading*

Preloading may be considered for reducing post-construction settlements of the subsoils under the proposed embankment widening. Preloading refers to the placement of fill either up to the proposed profile grade of the highway or a portion thereof (i.e. partial preload) in one or more stages to preconsolidate the underlying compressible soils in advance of the embankment completion and final pavement construction. Preloading reduces the magnitude of long-term, post-construction settlements by promoting such settlements to occur under the fill loads in advance of final grading of the embankment.

As discussed in Section 6.3.3.1, it is estimated that 90 per cent of the primary consolidation settlement under the loading due to conventional earth or granular fill will be completed within approximately nine to twelve months following placement of the fill for the embankment widening. After this period, less than 25 mm of primary consolidation settlement would remain below the embankment widening areas. With the use of lightweight fill materials (lightweight and ultra-lightweight slag fill as required to satisfy global stability requirements for Areas 3 and 4, respectively), the time period for preloading and the total magnitude of settlement will be reduced, as presented in Section 6.3.3.6.

The preload for the widening areas should be constructed up to the top of the highway granular sub-base. It is recommended that the required platform width be increased by 150 mm on each side of the existing embankment to accommodate the predicted settlement. After the preload period, it is recommended that additional sub-base fill be placed to achieve the final subgrade level prior to placement of the pavement structure.

6.3.3.6 *Settlement Mitigation – Lightweight Fill (Plus Preloading)*

Lightweight fill, such as lightweight slag, ultra-lightweight slag, cellular concrete or expanded polystyrene (EPS) could be used for the embankment widening to reduce the additional loading imposed on the underlying soils. The use of lightweight fill would reduce the load applied to the foundation soils due to the lower density of the fill materials, which in turn would reduce the magnitude of post-construction settlement. The lighter fill loading would reduce the predicted magnitude of the primary consolidation settlement under the embankment widening north of the South Canal bridges as follows:

Fill Option	Unit Weight (kN/m^3)	Estimated Maximum Primary Consolidation Settlement (mm)
Lightweight Slag	14	130
Ultra-Lightweight Slag	11	100
Cellular Concrete	5	40
EPS	0.5	10

As has been discussed in the preceding sections regarding global stability, the use of lightweight slag fill is required for the westward widening in Area 3, and the use of ultra-lightweight slag fill is required for the eastward widening in Area 4. These materials are considered the most cost-effective options to achieve the optimum factor of safety against global instability. With the use of these fill materials, the estimated primary consolidation settlement along the new (widened) crest of the Highway 400 embankment is summarized in the table below. For this magnitude of settlement in Area 4, a two-stage RSS wall is recommended.

Area	Approx. Station	Estimated Primary Consolidation Settlement (mm)
Area 3 (Westward Widening – Lightweight Slag Fill)	24+890	130
	24+940	100
	24+990	80
	25+040	70
	25+120	60
Area 4 (Eastward Widening – Ultra-Lightweight Slag Fill)	24+915	100
	24+975	100
	25+025	100
	25+075	80
	25+120	70

It has been estimated that the time to complete 90 per cent of the primary consolidation settlement for the embankment widening in Areas 3 and 4 will be approximately eight to nine months following the construction with the use of lightweight or ultra-lightweight slag fill materials. It is further estimated that less than about 10 mm of primary consolidation will remain after this time. It is understood that there is sufficient time in the construction schedule to accommodate this preloading period. An operational constraint has been provided in Appendix E for inclusion in the Contract Documents to address preloading. Monitoring of the settlement during the preloading period is recommended, as discussed further in Section 6.6.6.

For an RSS wall constructed using slag fill materials, up to about 25 mm of creep settlement could occur over a 10-year period following completion of construction.

Where lightweight slag fill / lightweight cellular concrete is adopted, it is recommended that an NSSP be included in the Contract Documents to address the supply, placement and compaction of the lightweight fill. This aspect is discussed further in Section 6.6.4, and an NSSP is provided in Appendix E.

6.3.3.7 *Settlement Mitigation – Wick Drains*

Where subexcavation is not practical (i.e. due to the thickness of or depth to the compressible soil deposits), and where the time required to achieve preconsolidation cannot be accommodated within the construction schedule, consideration may be given to installing wick drains in conjunction with preloading and surcharging to accelerate the rate of primary consolidation. Wick drains are prefabricated geotextile drains installed vertically from ground surface into or through soft, compressible soils to increase the rate of excess porewater pressure dissipation. Typically, wick drains are installed on a 1 m to 3 m triangular grid spacing over the footprint of the embankment widening.

A detailed assessment and design for wick drains would need to be carried out if other settlement mitigation measures (per Section 6.3.3.4 to 6.3.3.6 above) are not sufficient under the construction schedule. However, it is understood that a minimum period of 9 months is available for preloading based on the construction staging., and therefore the wick drain option has not been analyzed in greater detail as part of this report.

6.4 Retained Soil System (RSS) Walls

As discussed in Section 6.3, if the existing alignment of Wist Road is to be maintained, a retaining wall will be required to support the eastward widening of Highway 400 (Area 4). In order to accommodate the predicted magnitude of primary consolidation settlement (up to approximately 100 mm with the use of ultra-lightweight slag fill), a two-stage RSS wall is recommended. RSS walls should be designed for high performance and appearance in accordance with MTO Special Provision (SP) 599S22 and the Standard Special Provision for the design and construction of RSS walls dated September 2005. As noted in Section 6.3.2.3, with the use of ultra-lightweight slag fill there is some increased potential for corrosion of the metal reinforcing strips, and a modification to the SSP for RSS walls has been developed to address the requirement to design thicker reinforcing strips; this modified SSP is provided in Appendix E, for inclusion in the Contract Documents.

6.4.1 Founding Elevations

A typical RSS wall has front facing panels supported on compacted granular fill at a shallow depth below the ground surface in front of the wall. Typically, the facing panels and the reinforced soil mass should be founded below any existing topsoil/organic soils, unsuitable fill soils or other weak/soft soils. However, as the RSS wall in Area 4 will be constructed following subexcavation of the existing peat/organic materials, and backfilling with Granular B Type II, no additional subexcavation will be required for the proposed RSS wall. However, a minimum 0.3 m thick compacted Granular A pad should be used for levelling purposes below the permanent facing panels (which will be affixed in the second stage), and this pad should extend at least 0.5 m beyond the outside edge of both sides of the facing panels, then outward/downward at 1H:1V.

6.4.2 Geotechnical Resistance and Settlement

The factored geotechnical resistances at ULS given below may be used for design of the reinforced soil mass, for various RSS wall heights. These values assume that the reinforced soil mass acts as a unit and uses the full width of the reinforced soil mass, which can be taken as approximately 0.8 times the embankment height based on the results of the global stability analyses.

Wall Height	Assumed Reinforced Width	Factored Geotechnical Resistance at ULS
6 m	4.8 m	250 kPa
4 m	3.2 m	175 kPa
2.4 m	1.9 m	100 kPa

As discussed, the primary consolidation settlement will be approximately 100 mm behind the new north abutment for the South Canal bridges, decreasing to approximately 70 mm near Station 25+120, based on the use of ultra-lightweight slag fill. It is estimated that the period of time to complete 90 per cent of the primary consolidation settlement is approximately eight to nine months following placement of the fill for the embankment widening/retaining wall. Section 6.3.3.3 discusses settlement mitigation options.

A two-stage RSS wall is recommended to accommodate this estimated settlement; it will essentially act as a self-supporting “preload” in the first stage, and after the preloading period is completed as confirmed by settlement monitoring, the temporary facing panels will be affixed. The preloading period and timing for affixing the permanent facing panels have been addressed in the operational constraint in Appendix E, for inclusion in the Contract Documents. It is also recommended that the following notes be added to the Contract Drawings to address the requirement for a two-stage RSS wall:

- Two-stage RSS wall to be constructed with temporary facing; and
- Permanent RSS wall facing to be affixed after preloading and settlement are complete.

6.4.3 Global Stability

The global stability analyses for the RSS wall option is discussed in Section 6.3.2. It should be noted that the internal stability of a reinforced earth structure is to be designed and assessed by the proprietary product designer/supplier.

6.5 South Canal Berm – South Canal Bank Road, Station 9+860 to 10+150

Based on the design cross-sections, it is understood that South Canal will be realigned approximately 25 m to the south, with a berm constructed between the road and the canal. The cross-sections indicate that between approximately Station 9+910 and 10+100, the berm will be constructed over the infilled canal, which is to be backfilled to approximately Elevation 219 m. The top of the berm is proposed to be at approximately Elevation 221 m, and it will be about 1.5 m to 2 m high relative to the ground surface on its south side, and up to about 3 m high relative to the ditch line on its north side. The proposed water level in the canal is at approximately Elevation 218.8 m, with a design flood level of approximately Elevation 220.6 m.

It is recommended that the berm side slopes be constructed at 2H:1V above the canal water level, and at 3H:1V below the water level.

6.5.1 Subgrade Preparation

Based on the results for the pavement investigation in the vicinity of South Canal Bank Road, together with foundation boreholes advanced adjacent to the existing canal, some peat/organic soils are anticipated within the proposed footprint for the berm construction. In order to improve the stability and settlement performance of the berm, it is recommended that subexcavation of the peat/organic soils be completed; the depth of this subexcavation is anticipated to be approximately 2 m. The subexcavation may be backfilled with earth or granular fill; if subexcavation is completed in wet conditions, Granular B Type II is recommended for backfilling.

6.5.2 Berm Stability

Static slope stability analyses have been completed for the proposed South Canal realignment and berm placement using the commercially available program Slide from Rocscience, to check that a minimum factor of safety of 1.3 is achieved. This minimum Factor of Safety is considered appropriate for the proposed canal realignment and berm placement, considering the design requirements and the available field and laboratory testing data.

The following parameters have been used in the slope stability analyses, based on field and laboratory test data as well as accepted correlations (Bowles, 1984 and Kulhawy and Mayne, 1990):

Soil Deposit	Short-term (Undrained) Analysis			Long-term (Drained) Analysis		
	Bulk Unit Weight (kN/m^3)	Effective Friction Angle Φ’	Undrained Shear Strength (kPa)	Unit Weight (kN/m^3)	Effective Friction Angle Φ’	Cohesion (kPa)
New embankment fill	21	32°	-	21	32°	0
Existing embankment fill	19	28°	-	19	28°	0
Firm to very stiff clayey silt	19	-	45	19	30°	0
Soft to firm clayey silt	19	-	30	20	30°	0
Stiff to hard clayey silt till	21	-	200	21	34°	0
Compact to very dense sandy silt to silty sand	19	30°	-	19	30°	0

Providing that peat/organic soils are subexcavated from the footprint of the proposed berm, the slope stability analyses indicate that a Factor of Safety of at least 1.3 for global stability is achieved (see Figures 13 and 14 for static global stability results for both short-term (undrained) and long-term (drained) conditions).

6.5.3 Berm Settlement

Settlement analyses for the soils below the South Canal Road berm were carried out using both hand calculations and the commercially available computer program *Settle-3D* from Rocscience, using estimated elastic deformation moduli and consolidation settlement parameters as given in the table below, based on consolidations test results, correlations with the SPT “N” values, shear vanes and engineering judgement from experience with similar soils in this region of Ontario (Bowles, 1984; Kulhawy and Mayne, 1990; Peck et al., 1974). For the purpose of the settlement analyses it is assumed that all existing silty peat and very soft clayey silt soils (at the base of the canal) have been removed from the berm footprint prior to placing the fill material.

Soil Deposit	Bulk Unit Weight (kN/m^3)	Elastic Modulus (MPa)	P_c’ (kPa)	e_o	C_c	C_r
New Berm Fill (within existing canal under bridges)	20	-	-	-	-	-
Existing fill	21	25	–	–	–	–
Soft to firm clayey silt	19	25	140	0.64	0.16	0.025
Firm to very stiff clayey silt	19	25	-	-	-	-
Stiff to hard clayey silt till	21	60	-	-	-	-
Compact to very dense sandy silt to silty sand	20	80	–	–	–	–

Based on the settlement analyses, the primary consolidation settlement of the soils under the infilled canal and the new 2 m to 3 m high berm (constructed above the infilled canal) is estimated to be approximately 60 mm. The majority of this settlement is expected to occur within the soft to very stiff clayey silt deposit.

Preloading or other settlement mitigation measures may not be necessary for the berm area, as it is understood that the berm does not support infrastructure/utilities. However, if it is necessary to limit post-construction settlement, it has been estimated that the time to complete ninety per cent of the primary consolidation settlement of the soils beneath the berm and backfilled canal will be approximately 9 to 12 months following placement of the fill materials. It is estimated that approximately 5 mm to 10 mm of the primary settlement will remain approximately 12 months after placement of the fill for the backfilled canal and berm.

The above estimates do not include compression of the berm fill itself, which would occur during and after the construction of the embankment depending on the type of materials used. The magnitude of fill compression may range from 0.5 to 1 per cent of the height of the embankment, assuming approximately 98 per cent compaction of the embankment fill is achieved, relative to the material’s standard Proctor maximum dry density. In the case where granular fill is used for embankment construction, settlement of the fill itself is expected to occur essentially during embankment construction, whereas non-granular earth fill materials are expected to exhibit some additional settlement over time.

6.6 Construction Considerations

6.6.1 Subexcavation of Peat/Organic Materials

Based on the borehole information, layers of peat and/or organic soils were encountered, in some places below the fill, within the embankment widening and RSS wall construction areas. As discussed in Sections 6.2.1 and 6.3.1, these organic materials should be subexcavated from the plan limits of the embankment widening/retaining wall areas prior to fill placement, in order to achieve the minimum required factor of safety for global stability; this will also improve settlement performance of the embankments.

Temporary protection systems will be required along Highway 400, near the embankment toe, in order to permit subexcavation while minimizing impacts on the adjacent highway, and maintaining the stability of the excavation in order to be able to adequately remove the peat/organic soils. It is anticipated that on the “local road side” of the subexcavation, given the operational constraints for staged excavation as outlined below, temporary excavation slopes may be cut at 1H:1V provided that the excavation is immediately backfilled.

Staged subexcavation, in strips of limited width in “wet conditions” (i.e., without dewatering), will be required to maintain the stability of the excavation in Areas 3 and 4. As discussed in Section6.3.1, an Operational Constraint is provided in Appendix E to address the subexcavation requirements, including the following:

- Removal of the peat/organic soils and the overlying fill materials within the embankment widening and RSS wall footprints is to be carried out in short “strip” sections perpendicular to the Highway 400 and local road alignments, with the base of the excavation (as measured parallel to the toe of the Highway 400 embankment or local road) not wider than 3 m.
- Temporary excavation side slopes or back slopes through the peat/organic soils and overlying fill materials shall be no steeper than 1 horizontal to 1 vertical (1H:1V).

- Excavation and backfilling operations are to be carried out simultaneously in a manner that the excavation is not left open for more than the 3 m "strip" width at any given time.

6.6.2 Groundwater Control

The groundwater level is about 2.4 m below the grades of Wist Road and Davis Road and is approximately coincident with the underside of the peat deposit. It is anticipated that the excavations to remove the peat and organic soils will extend to or below the groundwater table at the site. The strip excavation work outlined in Section 6.6.1 may be carried out in wet conditions, without dewatering, provided that Granular B Type II backfill is used both below and above the water table to minimize segregation and to form a base for the subsequent construction of the embankment widening and RSS wall.

In the embankment widening area south of South Canal bridges the groundwater level is about coincident with the depth of subexcavation and it is anticipated that groundwater control can be handled by pumping from well filtered sumps.

6.6.3 Temporary Protection Systems

Where temporary protection systems are required along Highway 400 in conjunction with the subexcavation works, they should be designed and constructed in accordance with OPSS 539 (*Temporary Protection Systems).* The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539, provided that any existing adjacent structures or utilities can tolerate this magnitude of deformation. It is considered that a driven, interlocking sheet pile system would be most suitable for the temporary excavation support associated with the strip excavation work at this site, based on the subsurface soil and groundwater conditions.

The sheet piles or soldier piles would have to be driven or socketted to sufficient depth to provide the necessary passive resistance for the retained soil height under the temporary subexcavation works, including any surcharge loads behind the protection system within at least a 1H:1V zone relative to the base of the excavation.

The selection and design of the protection system will be the responsibility of the Contractor.

6.6.4 Use of Slag Fill for Embankment Widening

Lightweight and ultra-lightweight slag fill are required for the embankment widening and RSS wall construction in Areas 3 and 4, respectively. These materials will require special placement and compaction procedures to prevent overcrushing and overcompaction. NSSPs for the supply and placement of lightweight and ultra-lightweight slag fill are provided in Appendix E for inclusion in the Contract Documents.

In addition, an amendment to SSP 599S22 is recommended to address the requirements for thicker steel reinforcing strips for the RSS wall application, where slag fill is used; this amendment is provided in Appendix E for inclusion in the Contract Documents.

6.6.5 Preloading

As discussed in Section 6.2.3 and 6.3.3.6, the following provides the estimated magnitudes of settlement and the time to complete ninety per cent of primary consolidation under the embankment widening.

Embankment Widening Area	Estimated Settlement (mm)	Estimated Time to Complete 90 % of Primary Consolidation Settlement
Area 1 – Conventional Fill	Approx 50	2.5 months
Area 2 – Conventional Fill	N/A	N/A
Area 3 – Lightweight Slag Fill	130	9 months
Area 4 – Ultra-Lightweight Slag Fill	100	9 months

An operational constraint has been developed for inclusion in the Contract Documents, to address the timing requirements associated with the preloading of the embankment widening locations, including timing for placement of the permanent facing panels for the two stage RSS wall in Area 4.

6.6.6 Settlement Monitoring

It is recommended that settlement and deformation monitoring be carried out for the embankment widening and RSS wall construction, to monitor the magnitude and rate of settlement/deformation during the preloading period, and confirm the timing for completion of preloading.

A monitoring program has been developed, consisting of the following:

- Settlement plates and settlement pins, installed at the base of the fill platform and top of fill, respectively.
- Settlement profilers and shape accel arrays, installed at selected locations to supplement the information from the settlement plates and pins.
- Vibrating wire and standpipe piezometers, to monitoring groundwater levels and pore water pressures within and outside the widening area.
- Inclinometers, to monitoring lateral deformation of the embankment widening areas.

Instrumentation and monitoring plans and an NSSP for settlement monitoring are included in Appendix F, for inclusion in the Contract Documents. The related Foundation Monitoring Plan for the Contract Administrator Assignment has been provided under separate cover.

7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Sandra McGaghran, P.Eng. and Ms. Lisa Coyne, P.Eng., with technical input from Mr. Murty Devata, P.Eng., specialist foundations consultant. Mr. Jorge Costa, P.Eng., the Designated MTO Contact for Foundations for this project and Principal with Golder, provided quality control review of this report for conformance with the project Terms of Reference.

GOLDER ASSOCIATES LTD.

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13 Aug/15
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PROVINCE OF ONTARIO

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TWB/SMM/LCC/TJG/MSD/JMAC/sm

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Kulhawy, F.H. and Mayne, P.W. 1990. Manual on Estimating Soil Properties for Foundation Design. EL 6800, Research Project 1493-6. Prepared for Electric Power Research Institute, Palo Alto, California.

ASTM International:

ASTM D1586-08a	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D1587-08	Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91	Construction Projects
Ontario Regulation 443/09	Amendment to Ontario Regulation 213

Ontario Provincial Standard Specifications (OPSS)

OPSS 501	Construction Specification for Compacting
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 804	Construction Specification for Seed and Cover

Ontario Provincial Standard Drawings (OPSD)

OPSD 202.010	Slope Flattening Using Surplus Excavated Material on Earth or Rock Embankment
OPSD 208.010	Benching of Earth Slopes
OPSS 209	Construction Specification for Embankments over Swamps or Compressible Soils

Ontario Provincial Standard Drawings (OPSD)

OPSD 203.030	Embankments over Swamps Existing Slopes Maintained

Ontario Water Resources Act:

Ontario Regulation 903	Wells

TABLE 1 – COMPARISON OF ALTERNATIVES FOR WESTWARD EMBANKMENT WIDENING ADJACENT TO DAVIS ROAD (AREA 3)

Option	Advantages	Disadvantages	Constructability/ Construction Risk	Long-Term Performance	Costs
Additional subexcavation of very soft/soft clayey soil	• "Standard" construction equipment can be used to reach maximum excavation depth of 4.4 m below existing embankment toe • Does not require specialized materials (lightweight fill) or contractor/equipment (in situ ground improvement)	• Requires deeper excavation than peat alone, to 4.4 m below existing toe, with maximum 3 m strip widths envisaged • Protection system required along Highway 400, likely including two rows of low-capacity temporary anchors even with OPSS 209 and limited strip width • More backfill materials; wastage of backfill with OPSS 209 • Temporary impacts to Davis Road/ property access during excavation and backfilling	• Constructability challenges associated with excavating 3 m wide strips to a depth of 4.4 m, and backfilling immediately prior to excavation of adjacent strip • Slightly elevated, but still low risk of impacts to Highway 400 or local road due to deeper excavation depth, provided that protection system is appropriately designed and strip backfilling is completed immediately	• Poorer long-term embankment and pavement performance compared with other options; still approximately 40 mm of creep settlement in underlying clayey deposit	• Costs associated with protection system are higher for this option than for other options • Costs associated with losses due to depth and sloughing not accounted for in this estimate **Estimated Cost: $1,152K**
Lightweight fill – lightweight or ultra-lightweight slag *	• Shallower excavation, so smaller protection system, less backfill and wastage • Less risk to Highway 400/Davis Road during construction than with deeper subexcavation • Less primary and creep settlement (due to reduced embankment load) • MTO has good experience and performance with slag fill in RSS applications	• Peat removal still required, with subexcavation to approximately 2 m to 3 m • Protection system still required along Highway 400, though smaller than for first option, with soil anchors likely not required	• 3 m wide strips with immediate backfilling still challenging, but improved for 3 m subexcavation depth as compared with 4.4 m depth • Lower risk to Highway 400/Davis Road during excavation • Careful compaction of slag fill required to avoid particle breakage and overcompaction	• Low to negligible risk of long-term settlement performance issues compared to conventional fill for widening, as creep settlement will be reduced due to lighter load from embankment	• Material costs high, but lower cost for protection system, excavation and backfill versus deeper excavation **Estimated Cost: $686K** **PREFERRED OPTION FROM FOUNDATIONS PERSPECTIVE**
In situ ground improvement - deep soil mixing or aggregate piers	• Less subexcavation, so smaller protection system, less backfill and wastage • Less risk to highway/Davis Road during construction	• Peat removal still required, with subexcavation to approximately 2 m to 3 m after completion of in situ treatment • Protection system still required along Highway 400, though smaller than for first option, with soil anchors likely not required • Requires specialized designer/ contractor for in situ ground improvement	• 3 m wide strips with immediate backfilling still challenging, but improved for 3 m subexcavation depth as compared with 4.4 m depth • Lower risk to Highway 400/Davis Road during excavation	• Long-term settlement performance will be similar to that for first option (deeper subexcavation); although there may be some improvement in the settlement performance of the upper portion of the clayey deposit due to the ground improvement methods, this is difficult to predict at the current conceptual stage	• In situ treatment costs high, but lower cost for protection system, excavation and backfill versus deeper excavation. Note that the costs for the in situ ground treatment are based on a conceptual-level design only at this point, and further design refinement will be required. **Estimated Cost: $1,461K**

* **Notes:** For lightweight fill options for the westward widening of Highway 400 adjacent to Davis Road, with subexcavation of the peat materials only (i.e., avoiding deeper subexcavation of very soft/soft clayey soils):

- Granular A fill, earth fill, and ¼-inch chip stone are not sufficiently light; the factor of safety against global instability in the short-term is less than 1.3
- Lightweight and ultra-lightweight slag fill (Litex 4449 and 4443, respectively), have a factor of safety of approximately 1.3 against global instability in the short-term condition, increasing in the long-term condition.
- Lighter, more expensive fill materials (such as cellular concrete or EPS) are not considered necessary given that an appropriate factor of safety can be achieved using lightweight or ultra-lightweight slag fill.

TABLE 2 – COMPARISON OF ALTERNATIVES FOR EASTWARD EMBANKMENT WIDENING ADJACENT TO WIST ROAD (AREA 4)

Option (Wist Road)	Advantages	Disadvantages	Constructability/ Construction Risk	Long-Term Performance	Costs
Additional subexcavation of very soft/soft clayey soil	• "Standard" construction equipment can be used to reach maximum excavation depth of 5 m below existing embankment toe • Does not require specialized materials (lightweight fill) or contractor/equipment (in situ ground improvement)	• Requires deeper excavation than peat alone, to 5 m below existing toe, with maximum 3 m strip widths envisaged • Protection system required along Highway 400, likely including two rows of low-capacity temporary anchors even with OPSS 209 and limited strip width • More backfill materials; wastage of backfill with OPSS 209 • Temporary impacts to Wist Road/ property access during excavation and backfilling	• Constructability challenges associated with excavating 3 m wide strips to a depth of 5 m, and backfilling immediately prior to excavation of adjacent strip • Slightly elevated, but still low risk of impacts to Highway 400 or local road due to deeper excavation depth, provided that protection system is appropriately designed and strip backfilling is completed immediately	• Poorer long-term embankment and pavement performance compared with other options; still approximately 40 mm of creep settlement in underlying clayey deposit	• Costs associated with protection system are higher for this option than for other options • Costs associated with losses due to depth and sloughing not accounted for in this estimate **Estimated Cost: $2,840K**
Lightweight fill * (cellular concrete)	• Shallower excavation, so smaller protection system, less backfill and wastage • Less risk to highway/Wist Road during construction than deep subexcavation • Lowest primary and creep settlement as this is the lightest-weight fill option	• Peat removal still required, with subexcavation to approximately 3 m • Protection system still required along Highway 400, though smaller than for first option, with soil anchors likely not required • RSS treatment using lightweight cellular concrete is not on MTO's DSM list	• 3 m wide strips with immediate backfilling still challenging, but improved for 3 m subexcavation depth as compared with 5 m depth • Lower risk to Highway 400/Wist Road during excavation • Low to negligible risk of long-term settlement performance issues	• Lowest risk of long-term settlement performance issues compared to conventional fill or slag fill for widening, as creep settlement will be reduced due to lighter loading • Use of cellular concrete is relatively newer in RSS application, and MTO does not have a history of experience on 400-series highways, although it has been used in USDOTs	• Material costs high, but lower cost for protection system, excavation and backfill versus deeper excavation **Estimated Cost: $2,310K**
Lightweight fill * (ultra-lightweight slag – Litex 4443)	• Shallower excavation, so smaller protection system, less backfill and wastage • Less risk to highway/Wist Road during construction than deep subexcavation • Less primary and creep settlement (reduced load) • MTO has good experience and performance with slag fill in RSS applications	• Peat removal still required, with subexcavation to approximately 3 m • Protection system still required along Highway 400, though smaller than for first option, with soil anchors likely not required	• 3 m wide strips with immediate backfilling still challenging, but improved for 3 m subexcavation depth as compared with 5 m depth • Lower risk to Highway 400/Wist Road during excavation • Careful compaction of slag fill required to avoid particle breakage and overcompaction	• Lower risk of long-term settlement performance issues compared to conventional fill for widening, as creep settlement will be reduced due to lighter load from embankment/RSS wall • MTO has good experience and performance with slag backfill in RSS applications. There is some potential for corrosion of steel reinforcement, and therefore the use of thicker steel strips (a "sacrificial thickness to allow for some loss due to corrosion) is recommended. Alternatively, specialized plastic reinforcement strips could be used to avoid potential for corrosion of metal reinforcing strips; however, this application is not presently approved on MTO's DSM list.	• Material costs high, but lower cost for protection system, excavation and backfill versus deeper excavation **Estimated Cost: $1,966K** **PREFERRED OPTION FROM FOUNDATIONS PERSPECTIVE**

Option (Wist Road)	Advantages	Disadvantages	Constructability/ Construction Risk	Long-Term Performance	Costs
In situ ground improvement - deep soil mixing or aggregate piers	• Less subexcavation, so smaller protection system, less backfill and wastage • Less risk to highway/Wist Road during construction	• Peat removal still required, with subexcavation to approximately 3 m after completion of in situ treatment • Protection system still required along Highway 400, though smaller than for first option, with soil anchors likely not required • Requires specialized designer/ contractor for in situ ground improvement	• 3 m wide strips with immediate backfilling still challenging, but improved for 3 m subexcavation depth as compared with 5 m depth • Lower risk to Highway 400/Wist Road during excavation, and less potential for impact on adjacent agricultural business	• Long-term settlement performance will be similar to that for first option (deeper subexcavation); although there may be some improvement in the settlement performance of the upper portion of the clayey deposit due to the ground improvement methods, this is difficult to predict at the current conceptual stage	• In situ treatment costs high, but lower cost for protection system, excavation and backfill versus deeper excavation. Note that the costs for the in situ ground treatment are based on a conceptual-level design only at this point, and further design refinement will be required. **Estimated Cost: $3,164K**

* **Notes:** With respect to lightweight fill material options for the construction of the RSS wall adjacent to Wist Road:

- Only cellular concrete (5 kN/m^3) or ultra-lightweight slag fill (Litex 4443, 11 kN/m^3) are able to achieve a minimum factor of safety against global instability of 1.3 or greater under short-term loading conditions.
- All other lightweight fill materials (Litex 4449, combined EPS and granular, and ¼-inch chip stone) have lower factors of safety and are not feasible, unless deeper subexcavation is also adopted.

MINISTRY OF TRANSPORTATION, ONTARIO

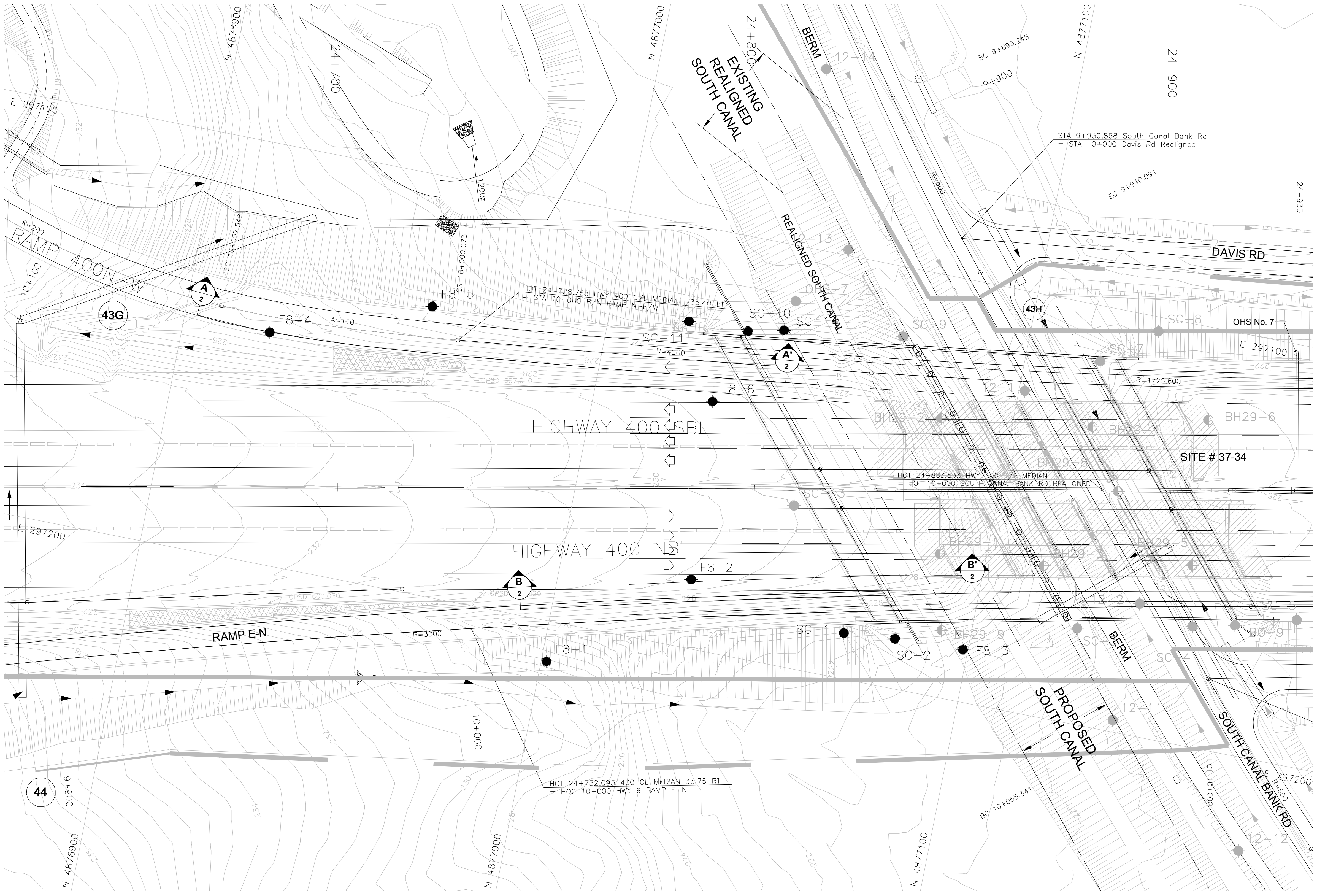
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No. 2015-2004
GWP No. 2025-13-00

HIGHWAY 400 WIDENING
STA 24+650 TO STA 24+840
BOREHOLE LOCATIONS

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN
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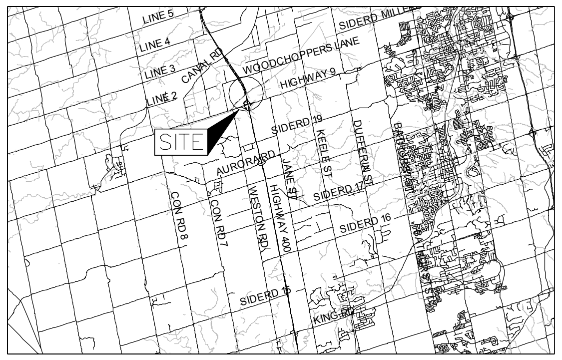


KEY PLAN
SCALE
4 0 4 8 km

LEGEND

● Borehole – Current Investigation by Golder

◐ Borehole – Previous Investigation (Geocres No. 31D-029)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
F8-1	227.3	4877001.3	297209.6
F8-2	229.2	4877031.6	297183.6
F8-3	221.0	4877098.8	297187.5
F8-4	227.0	4876920.8	297144.9
F8-5	223.8	4876957.9	297131.3
F8-6	229.1	4877028.4	297140.7
SC-1	223.0	4877070.0	297189.1
SC-2	222.0	4877082.3	297188.1
SC-10	222.1	4877033.5	297122.5
SC-11	221.8	4877019.1	297122.9
SC-14	222.0	4877041.9	297120.6

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans and General Arrangement provided in digital format by URS Canada Inc., (Drawing Files "Hwy400_plan.dwg" and "01_GA_July 10 2012.dwg") received November 13, 2013 and September 26, 2012.

L.C. COYNE
Jan. 12, 2015

J.M.A. COSTA
Jan. 12, 2015

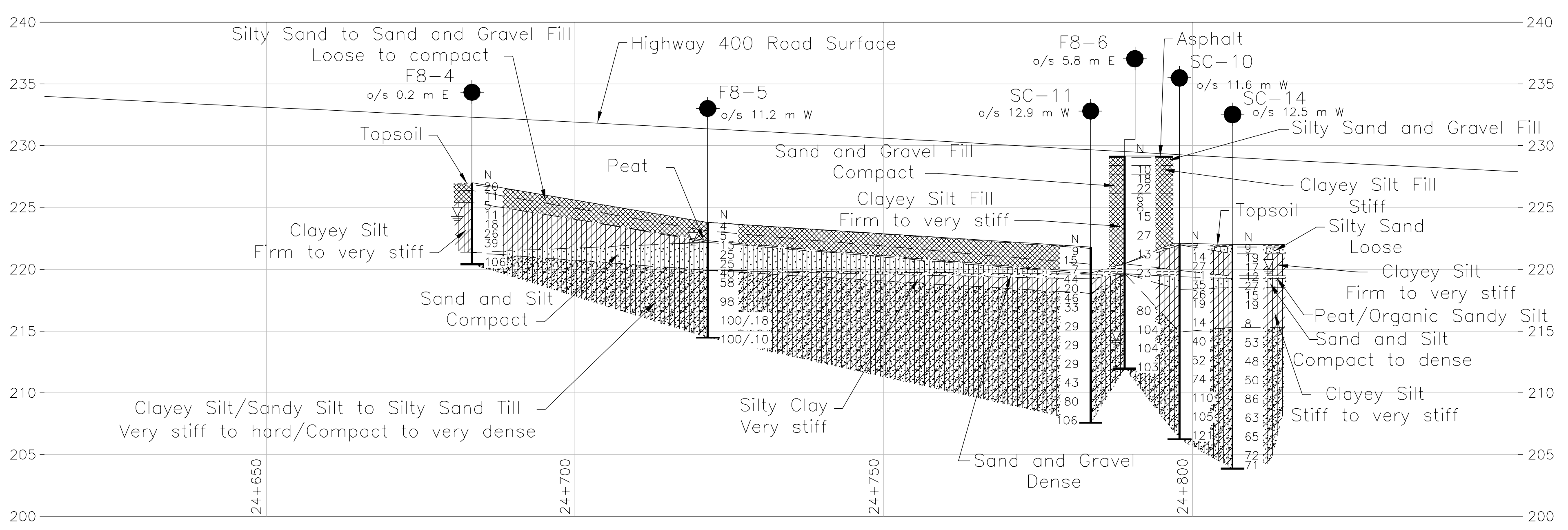
NO.	DATE	BY	REVISION

Geocres No. 31D-576

HWY. 400		PROJECT NO. 09-1111-0018	DIST.CENTRAL
SUBM'D. TWB	CHKD. SMM	DATE: Nov. 2013	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG.1

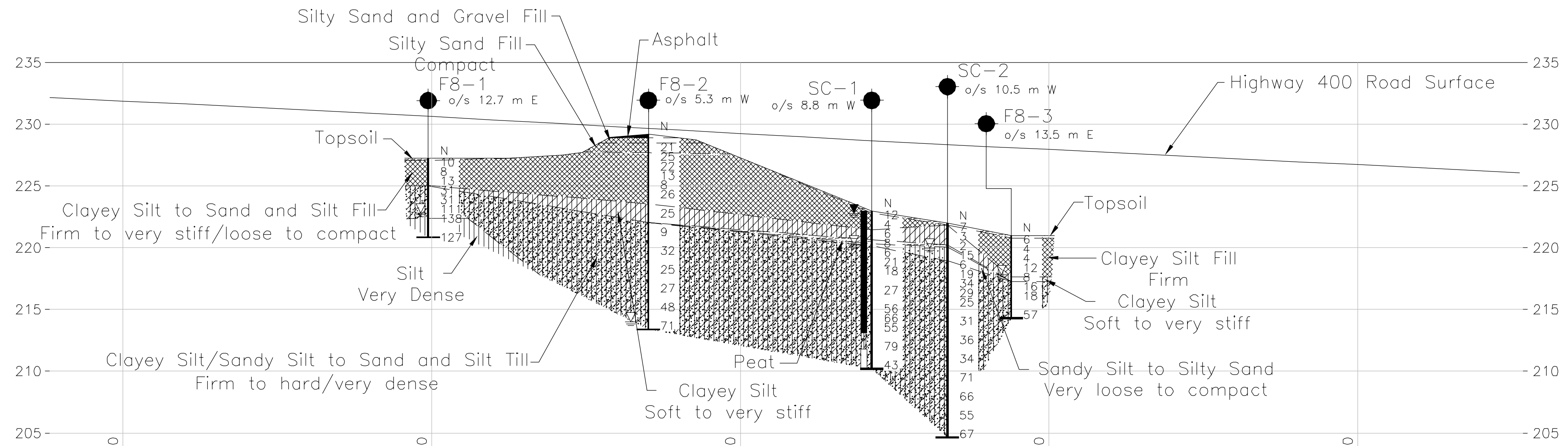
PLOT DATE: January 12, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (URS, York Region)\-IB- South Canal-Embankment (Stamps)\0911110018IB001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO



A-A' 1 HIGH FILL EMBANKMENT AREA 8-SBL PROFILE
(STATION 24+650 TO STATION 24+810)

HORIZONTAL SCALE
10 0 10 20 m
5 0 5 10 m
VERTICAL SCALE



B-B' 1 HIGH FILL EMBANKMENT AREA 8-NBL PROFILE
(STATION 24+740 TO STATION 24+840)

HORIZONTAL SCALE
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5 0 5 10 m
VERTICAL SCALE

METRIC
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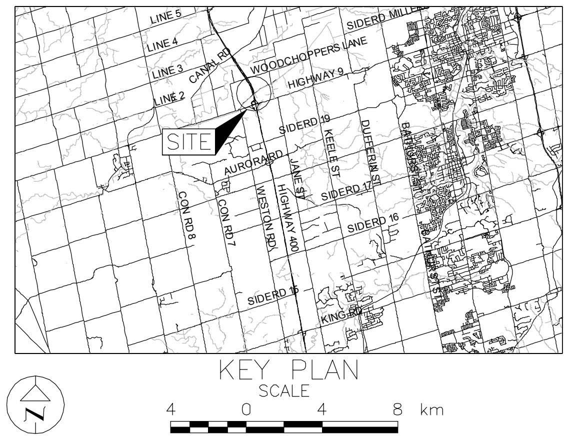
STATIONS IN KILOMETRES + METRES.

CONT No. 2015-2004
GWP No. 2025-13-00

HIGHWAY 400 WIDENING
STA 24+650 TO STA 24+840
SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE

LEGEND

●	Borehole – Current Investigation
▮	Seal
▯	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
▼	WL in piezometer, measured on June 12, 2012
▽	WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
F8-1	227.3	4877001.3	297209.6
F8-2	229.2	4877031.6	297183.6
F8-3	221.0	4877098.8	297187.5
F8-4	227.0	4876920.8	297144.9
F8-5	223.8	4876957.9	297131.3
F8-6	229.1	4877028.4	297140.7
SC-1	223.0	4877070.0	297189.1
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SC-10	222.1	4877033.5	297122.5
SC-11	221.8	4877019.1	297122.9
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REFERENCE

Ground Surface Line cut from a digital file by URS, drawing file no. Hwy400_contours.dwg, received July 12, 2011.

L.C. COYNE
Jan. 12, 2015

J.M.A. COSTA
Jan. 12, 2015

NO.	DATE	BY	REVISION

Geocres No. 31D-576

HWY. 400		PROJECT NO. 09-1111-0018	DIST.CENTRAL
SUBM'D. TWB	CHKD. SMM	DATE: Nov. 2013	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG.2

PLOT DATE: January 12, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (URS, York Region)\-IB- South Canal-Embankment (Stamps)\0911110018IB002.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

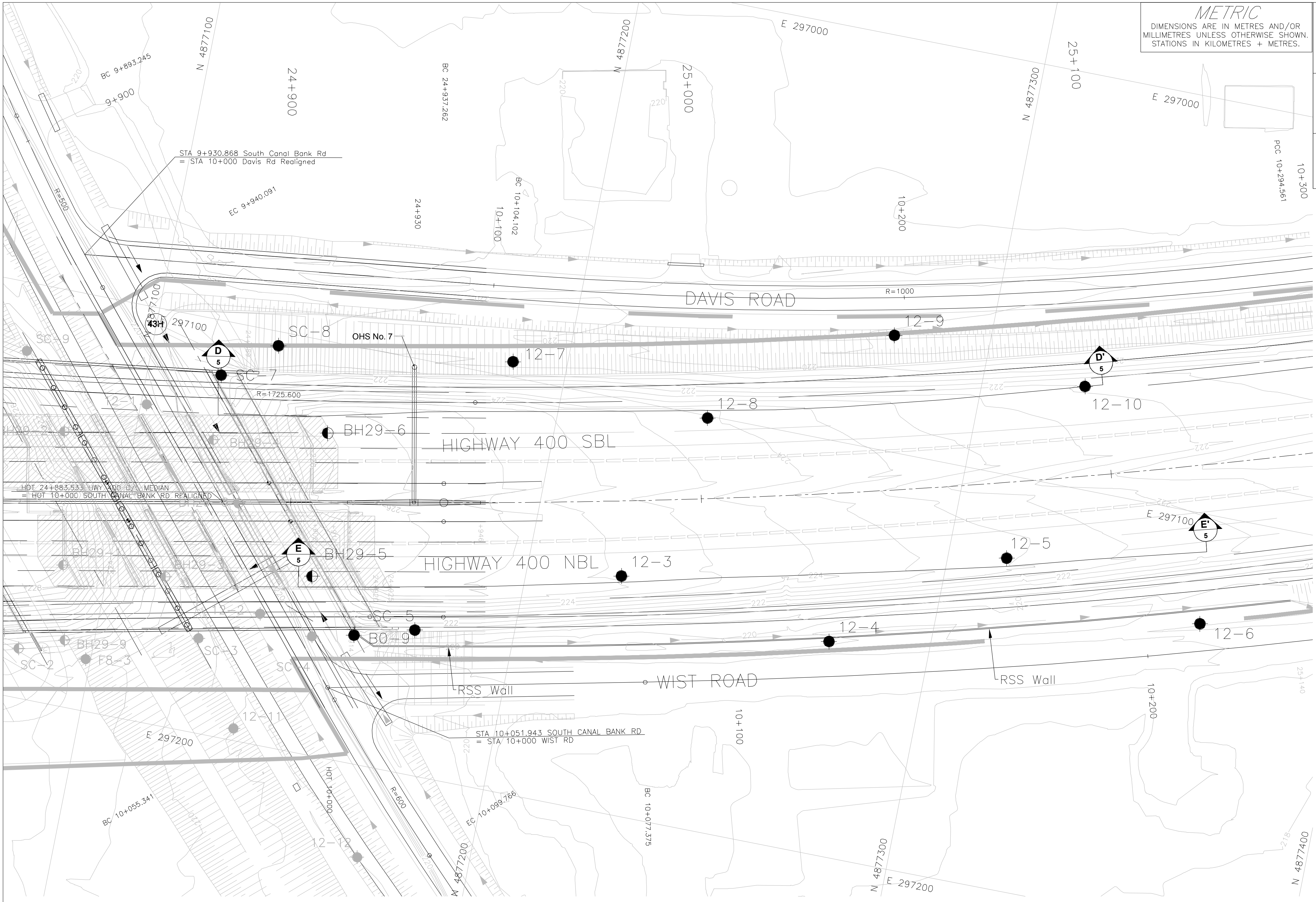
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2015–2004
GWP No. 2025–13–00

SHEET

HIGHWAY 400 WIDENING
STATION 24+880 to STATION 25+120
BOREHOLE LOCATIONS

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN
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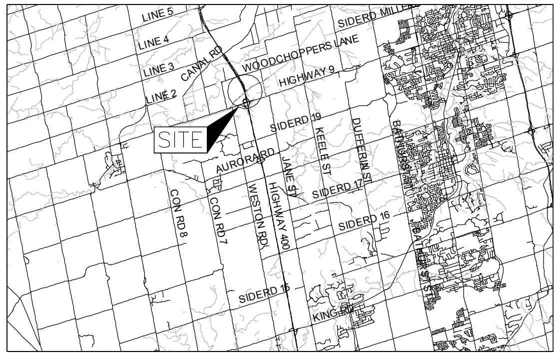

KEY PLAN
SCALE
4 0 4 8 km

LEGEND

- ● Borehole – Current Investigation by Golder
- ◐ Borehole – Previous Investigation (Geocres No. 31D–029)

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
12–3	225.0	4877222.9	297142.4
12–4	219.5	4877275.6	297148.2
12–5	223.5	4877314.1	297119.9
12–6	219.7	4877363.4	297126.5
12–7	220.4	4877186.9	297096.2
12–8	224.1	4877236.1	297100.5
12–9	219.5	4877276.8	297071.9
12–10	222.0	4877324.8	297075.2
B0–9	221.0	4877161.8	297169.1
BH29–5	221.1	4877149.0	297157.0
BH29–6	225.8	4877146.0	297122.0
SC–5	221.1	4877176.1	297165.0
SC–7	220.7	4877117.8	297113.1
SC–8	220.5	4877130.1	297103.5

NOTES

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Jan. 12, 2015

J.M.A. COSTA
Jan. 12, 2015

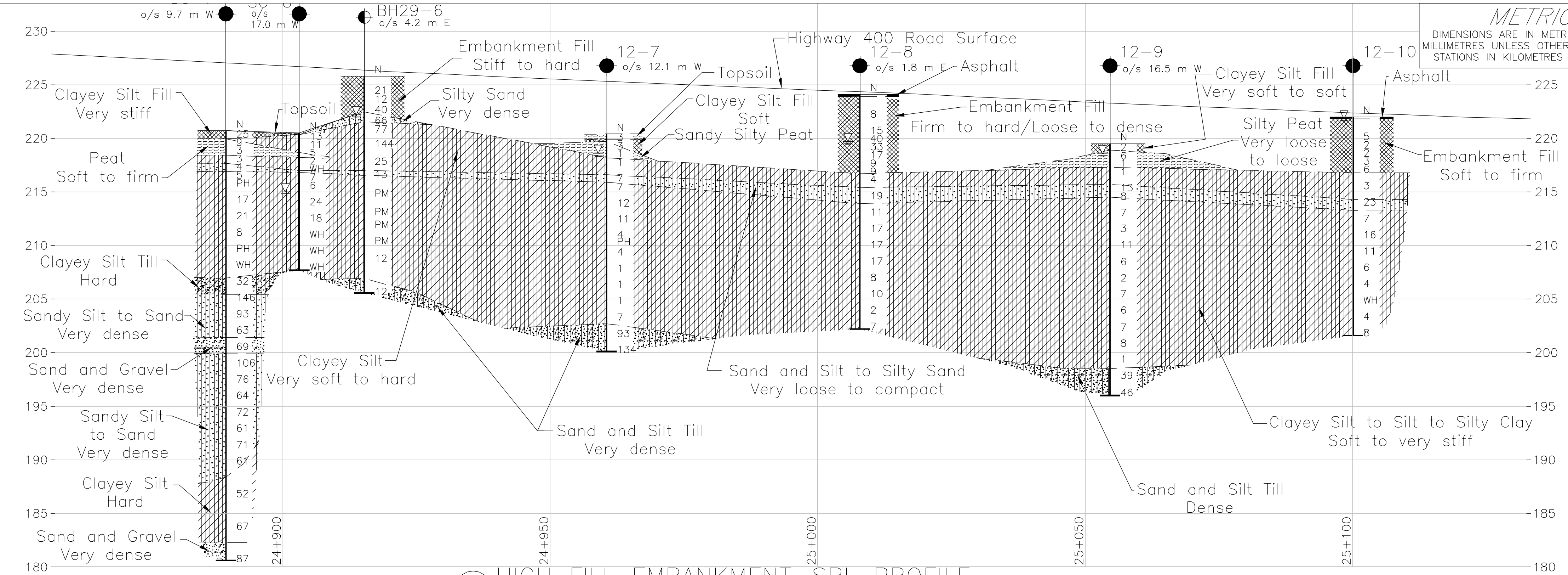
NO.	DATE	BY	REVISION

Geocres No. 31D–576

HWY. 400		PROJECT NO. 09–1111–0018	DIST. CENTRAL
SUBM'D. TWB	CHKD. SMM	DATE: Nov. 2013	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG. 3

PLOT DATE: January 13, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (URS, York Region)\-IB- South Canal-Embankment (Stamps)\09111100181B003.dwg

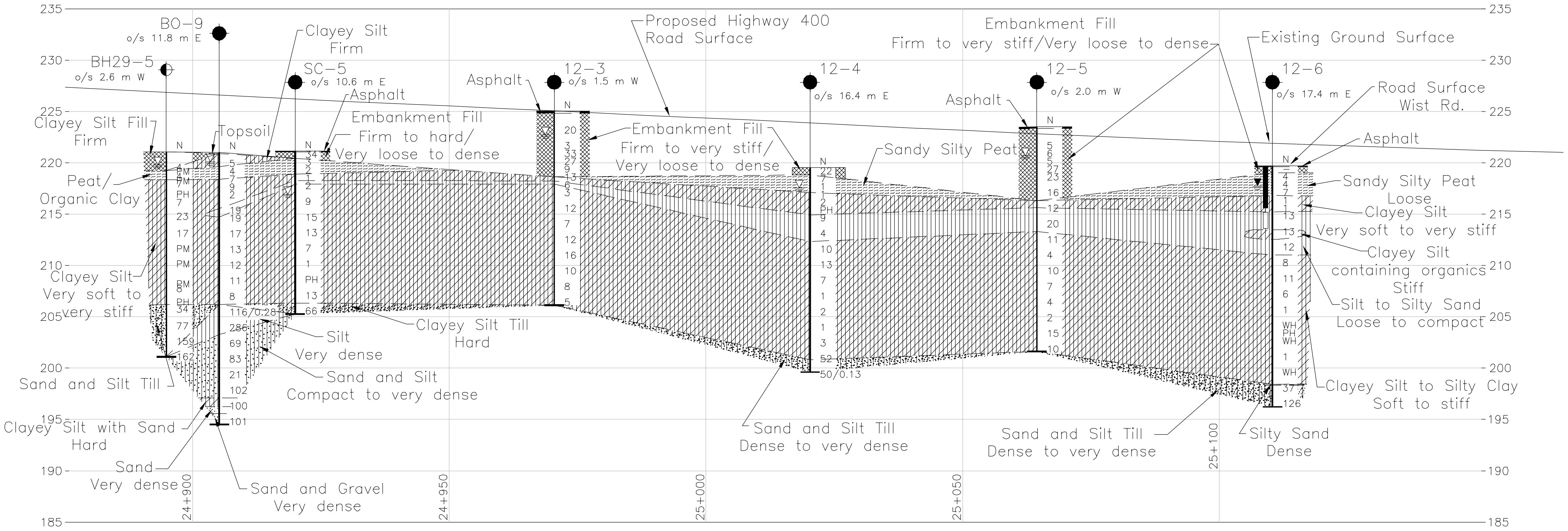
MINISTRY OF TRANSPORTATION, ONTARIO



D-D'
4

HIGH FILL EMBANKMENT–SBL PROFILE
(STATION 24+880 to STATION 25+120)

HORIZONTAL SCALE
10 0 10 20 m
5 0 5 10 m
VERTICAL SCALE



E-E'
4

HIGH FILL EMBANKMENT–NBL PROFILE
(STATION 24+900 to STATION 25+120)

HORIZONTAL SCALE
10 0 10 20 m
5 0 5 10 m
VERTICAL SCALE

REFERENCE

Ground Surface Line cut from a digital file by URS, drawing files no. Hwy400_contours.dwg, received July 12, 2011 and Hwy400_profile_July 2013.dwg, received July 25, 2013.

METRIC

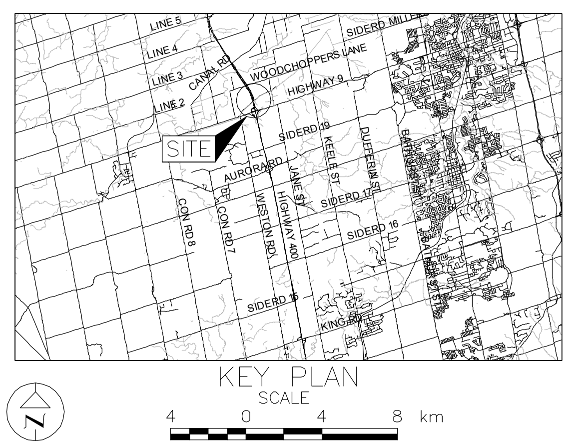
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2015–2004
GWP No. 2025–13–00

HIGHWAY 400 WIDENING
STATION 24+880 to STATION 25+120
SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE
4 0 4 8 km

LEGEND

- ● Borehole – Current Investigation
- ⊕ Borehole – Previous Investigation (Geocres No. 31D–029)
- ▮ Seal
- ▯ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ▼ WL in piezometer, measured on June 12, 2013
- ▽ WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
12-3	225.0	4877222.9	297142.4
12-4	219.5	4877275.6	297148.2
12-5	223.5	4877314.1	297119.9
12-6	219.7	4877363.4	297126.5
12-7	220.4	4877186.9	297096.2
12-8	224.1	4877236.1	297100.5
12-9	219.5	4877276.8	297071.9
12-10	222.0	4877324.8	297075.2
BO-9	221.0	4877161.8	297169.1
BH29-5	221.1	4877149.0	297157.0
BH29-6	225.8	4877146.0	297122.0
SC-5	221.1	4877176.1	297165.0
SC-7	220.7	4877117.8	297113.1
SC-8	220.5	4877130.1	297103.5

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

L.C. COYNE Jan. 12, 2015

J.M.A. COSTA Jan. 12, 2015

NO.	DATE	BY	REVISION

Geocres No. 31D–576

HWY. 400		PROJECT NO. 09–1111–0018	DIST. CENTRAL
SUBM'D. TWB	CHKD. SMM	DATE: July 2013	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG. 4

PLOT DATE: January 12, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (URS, York Region)\-IB- South Canal-Embankment (Stamps)\0911110018IB004.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

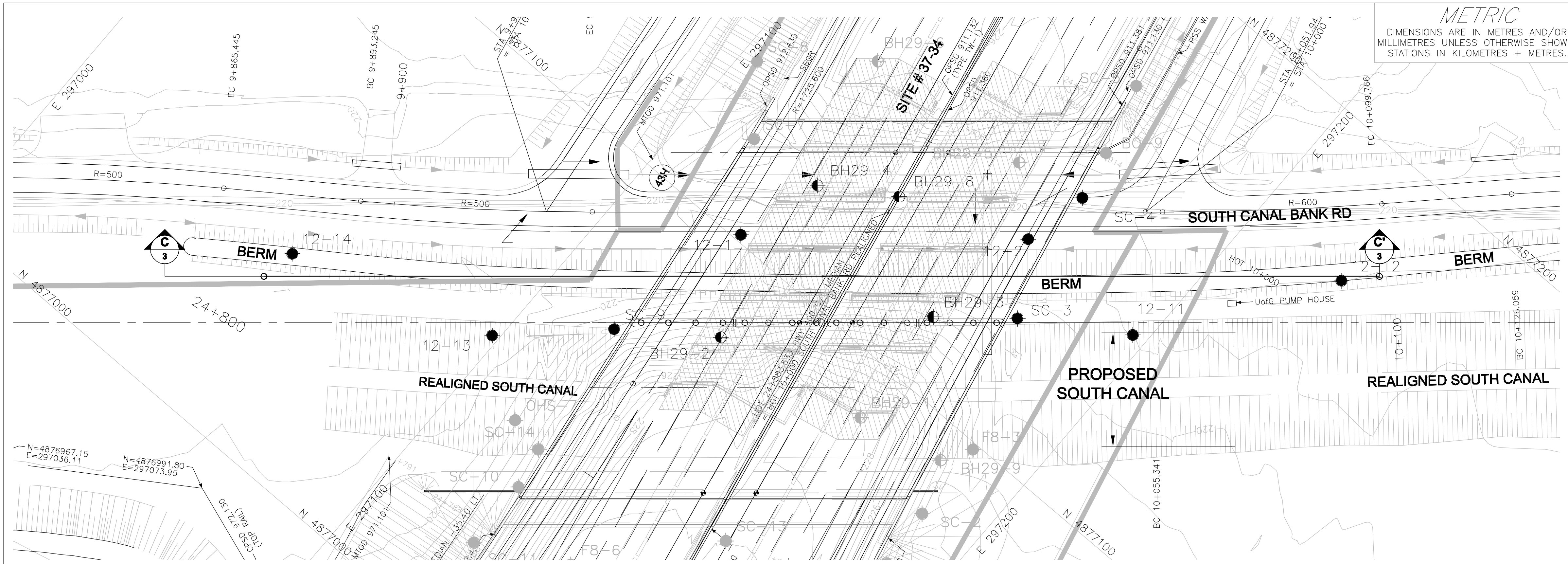
CONT No. 2015–2004
GWP No. 2025–13–00

HIGHWAY 400 WIDENING
SOUTH CANAL BANK ROAD
STATION 9+860 to STATION 10+100
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

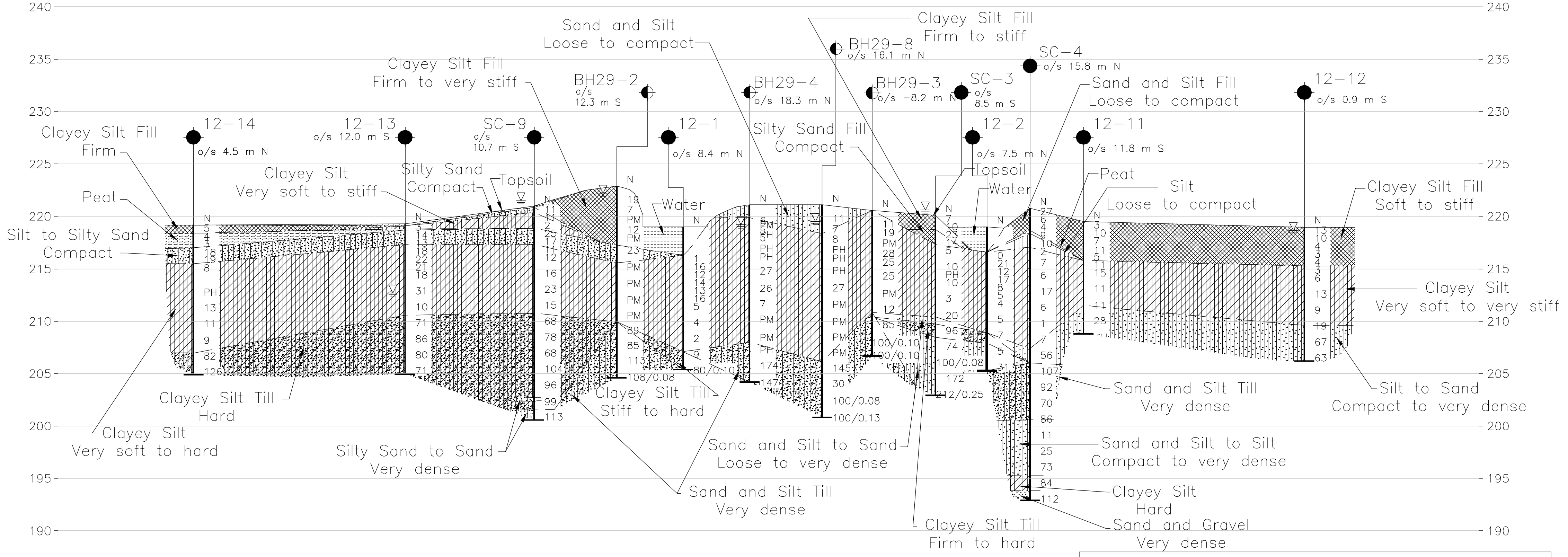
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.



PLAN

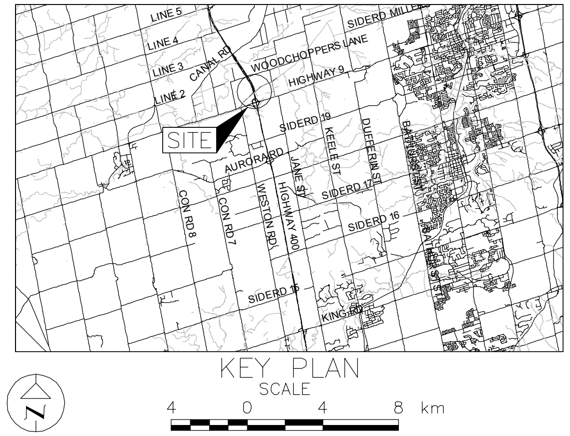
SCALE
10 0 10 20 m



SOUTH CANAL BERM–CENTERLINE PROFILE
STATION 9+860 TO STATION 10+100

C-C' 3

HORIZONTAL SCALE
10 0 10 20 m
5 0 5 10 m
VERTICAL SCALE



KEY PLAN
SCALE
4 0 4 8 km

LEGEND

●	Borehole – Current Investigation by Golder
◐	Borehole – Previous Investigation (Geocres No. 31D–029)
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
⊻	WL upon completion of drilling

BOREHOLE CO–ORDINATES

No.	ELEVATION	NORTHING	EASTING
12–1	219.0	4877101.4	297123.6
12–2	219.0	4877138.4	297168.4
12–11	219.5	4877137.4	297197.1
12–12	219.0	4877173.1	297222.1
12–13	219.3	4877053.3	297098.6
12–14	219.2	4877039.6	297057.1
BH29–2	223.9	4877083.0	297134.0
BH29–3	220.6	4877114.0	297164.0
BH29–4	221.1	4877119.0	297129.0
BH29–8	221.1	4877128.0	297143.0
SC–3	220.1	4877124.8	297177.2
SC–4	220.8	4877151.8	297171.4
SC–9	221.0	4877070.2	297116.5

L.C. COYNE
Jan 12, 2015

J.M.A. COSTA
Jan. 12, 2015

REFERENCE

Base plans and General Arrangement provided in digital format by URS Canada Inc., (Drawing Files "Hwy400_plan.dwg" and "01_GA_July 10 2012.dwg") received November 13, 2013 and September 26, 2012.

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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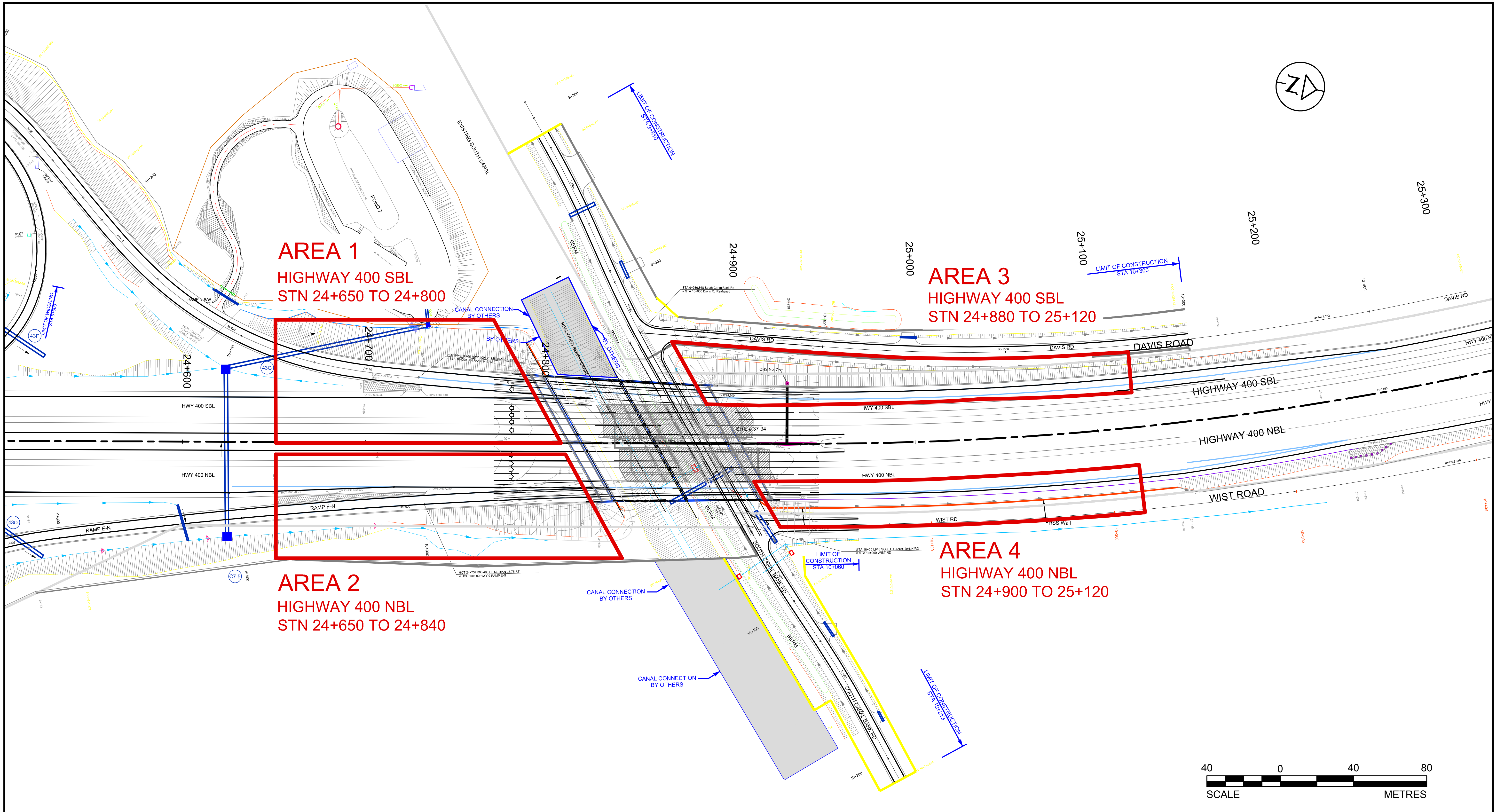
NO.	DATE	BY	REVISION

Geocres No. 31D–576

HWY. 400		PROJECT NO. 09–1111–0018	DIST. CENTRAL
SUBM'D. TWB	CHKD. SMM	DATE: July 2013	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG. 5

PLOT DATE: January 12, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (URS, York Region)\-IB- South Canal-Embankment (Stamps)\0911110018IB005.dwg



LEGEND:

🟥	EMBANKMENT WIDENING AREAS

REFERENCES:

Base plan and General Arrangement provided in digital format by URS Canada Inc., (Drawing Files "Hwy400_plan.dwg" and "01_GA_July 10 2012.dwg") received November 13, 2013 and September 26, 2012.

PROJECT

MTO
HIGHWAY 400 WIDENING
YORK REGION

TITLE

EMBANKMENT WIDENING AREAS
INDEX PLAN

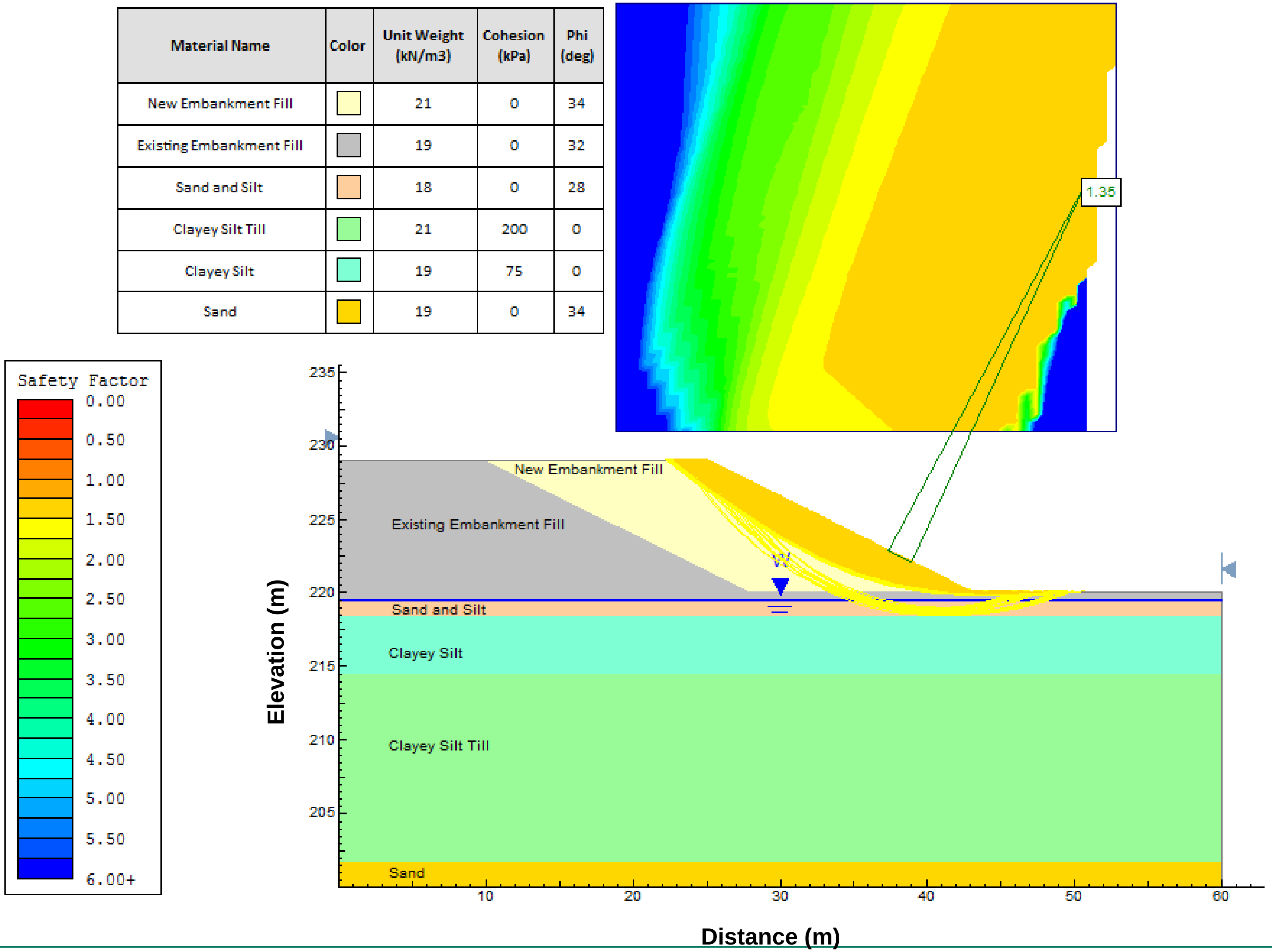
Golder Associates
Mississauga, Ontario, Canada

PROJECT No.	09-1111-0018	FILE No. 0911110018XA001.dwg	
DESIGN		SCALE AS SHOWN	REV.
CAD	JFC	Aug. 11, 2015	FIGURE
CHECK	LCC	Aug. 11, 2015	
REVIEW			1

PLOT DATE: August 11, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (URS, York Region)\-XA- Embankment widening\0911110018XA001.dwg

Static Global Stability – Area 1 (Station 24+680)
Short-Term (Undrained) Conditions

Figure 2



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
New Embankment Fill	🟨	21	0	34
Existing Embankment Fill	⬜	19	0	32
Sand and Silt	🟧	18	0	28
Clayey Silt Till	🟩	21	200	0
Clayey Silt	🟦	19	75	0
Sand	🟨	19	0	34

Date: November 2013

Project No: 09-1111-0018

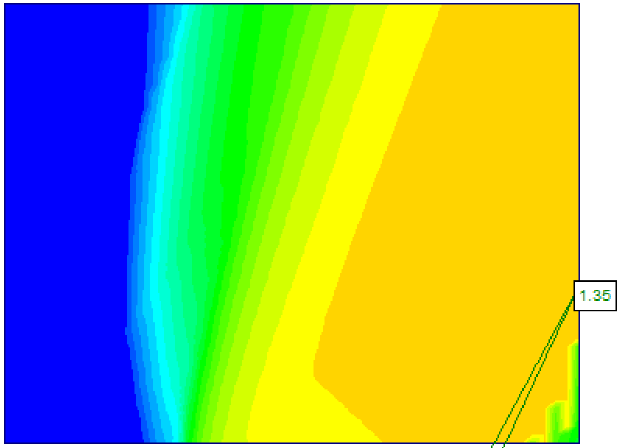
Analysis By: TWB **Reviewed By:** SMM

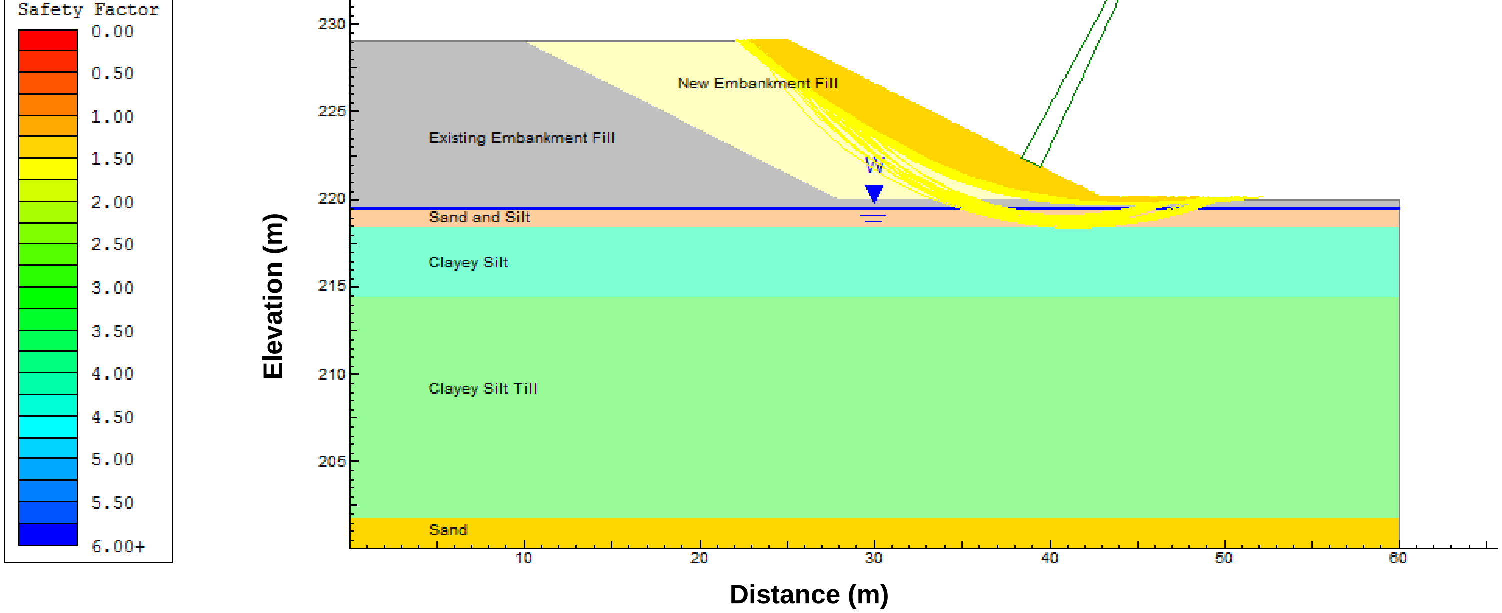
Golder Associates

Static Global Stability – Area 1 (Station 24+680) Long-Term (Drained) Conditions

Figure 3

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
New Embankment Fill	🟨	21	0	34
Existing Embankment Fill	⬜	19	0	32
Sand and Silt	🟧	18	0	28
Clayey Silt Till	🟩	21	0	32
Clayey Silt	🟦	19	0	30
Sand	🟨	19	0	34





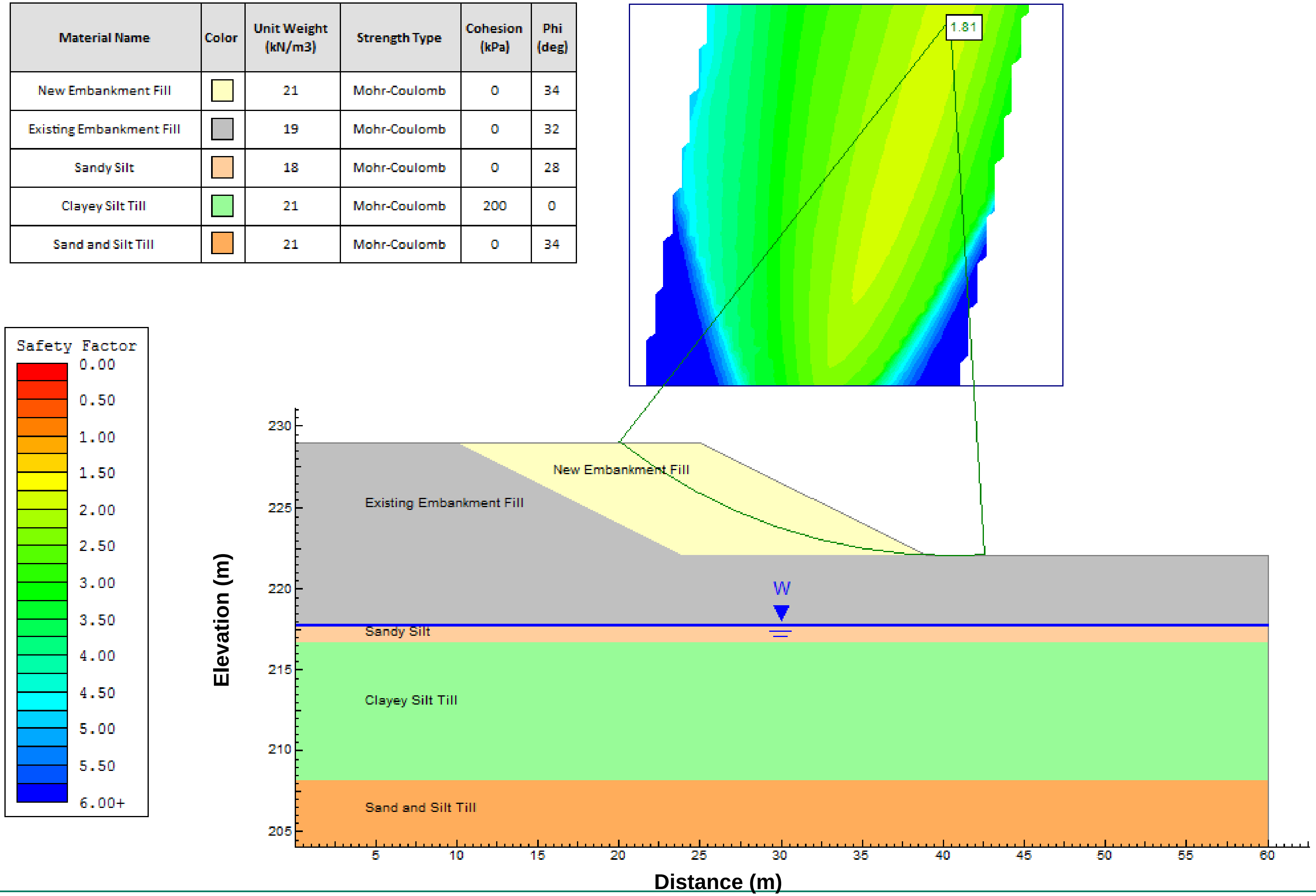
Date: November 2013

Project No: 09-1111-0018

Analysis By: TWB **Reviewed By:** SMM

Static Global Stability – Area 2 (Station 24+680)
Short-Term (Undrained) Conditions

Figure 4



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankment Fill	🟨	21	Mohr-Coulomb	0	34
Existing Embankment Fill	⬜	19	Mohr-Coulomb	0	32
Sandy Silt	🟧	18	Mohr-Coulomb	0	28
Clayey Silt Till	🟩	21	Mohr-Coulomb	200	0
Sand and Silt Till	🟧	21	Mohr-Coulomb	0	34

Date: November 2013

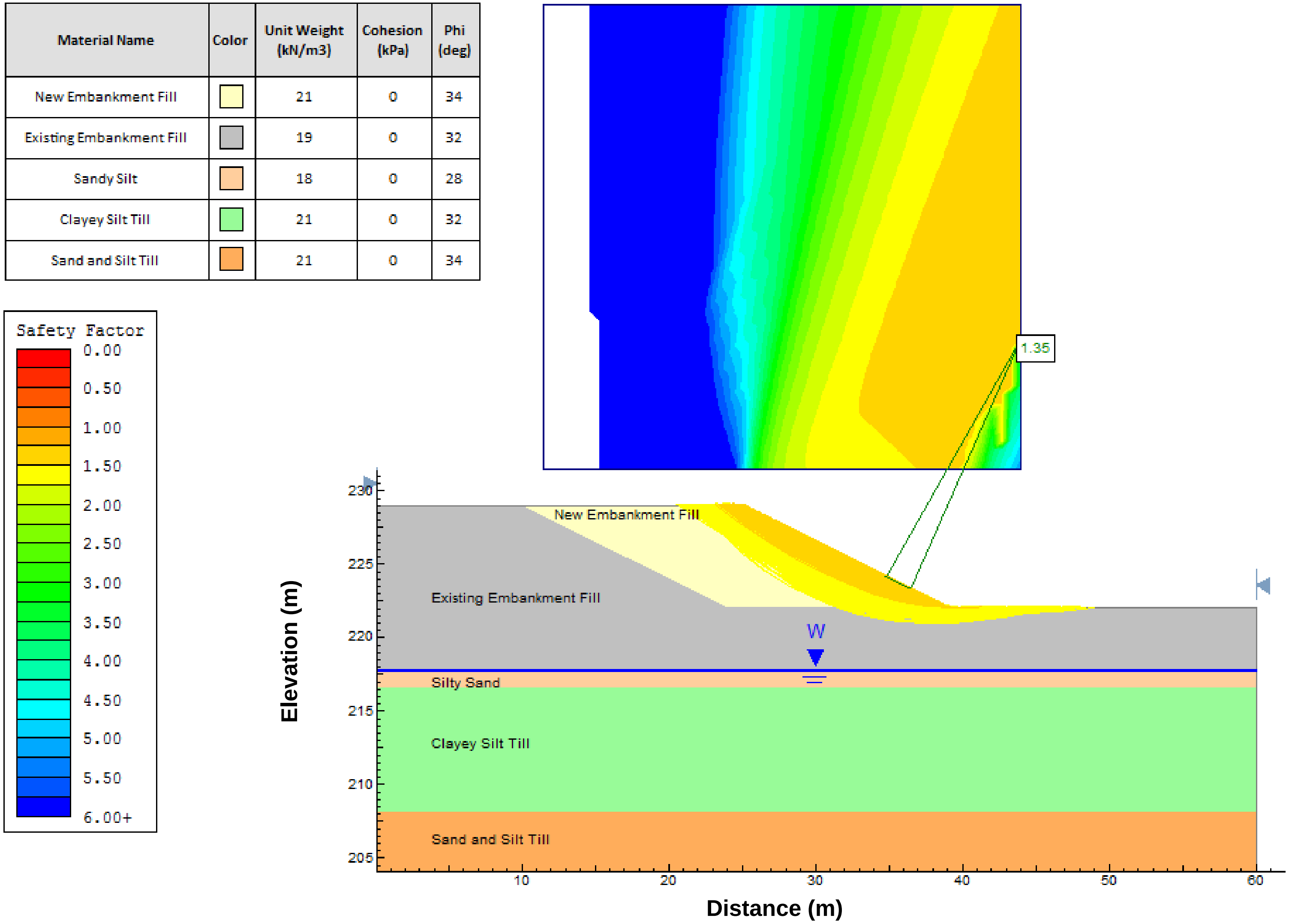
Project No: 09-1111-0018

Analysis By: TWB **Reviewed By:** SMM

Static Global Stability – Area 2 (Station 24+680) Long-Term (Drained) Conditions

Figure 5

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
New Embankment Fill	🟨	21	0	34
Existing Embankment Fill	⬜	19	0	32
Sandy Silt	🟧	18	0	28
Clayey Silt Till	🟩	21	0	32
Sand and Silt Till	🟧	21	0	34



Date: November 2013

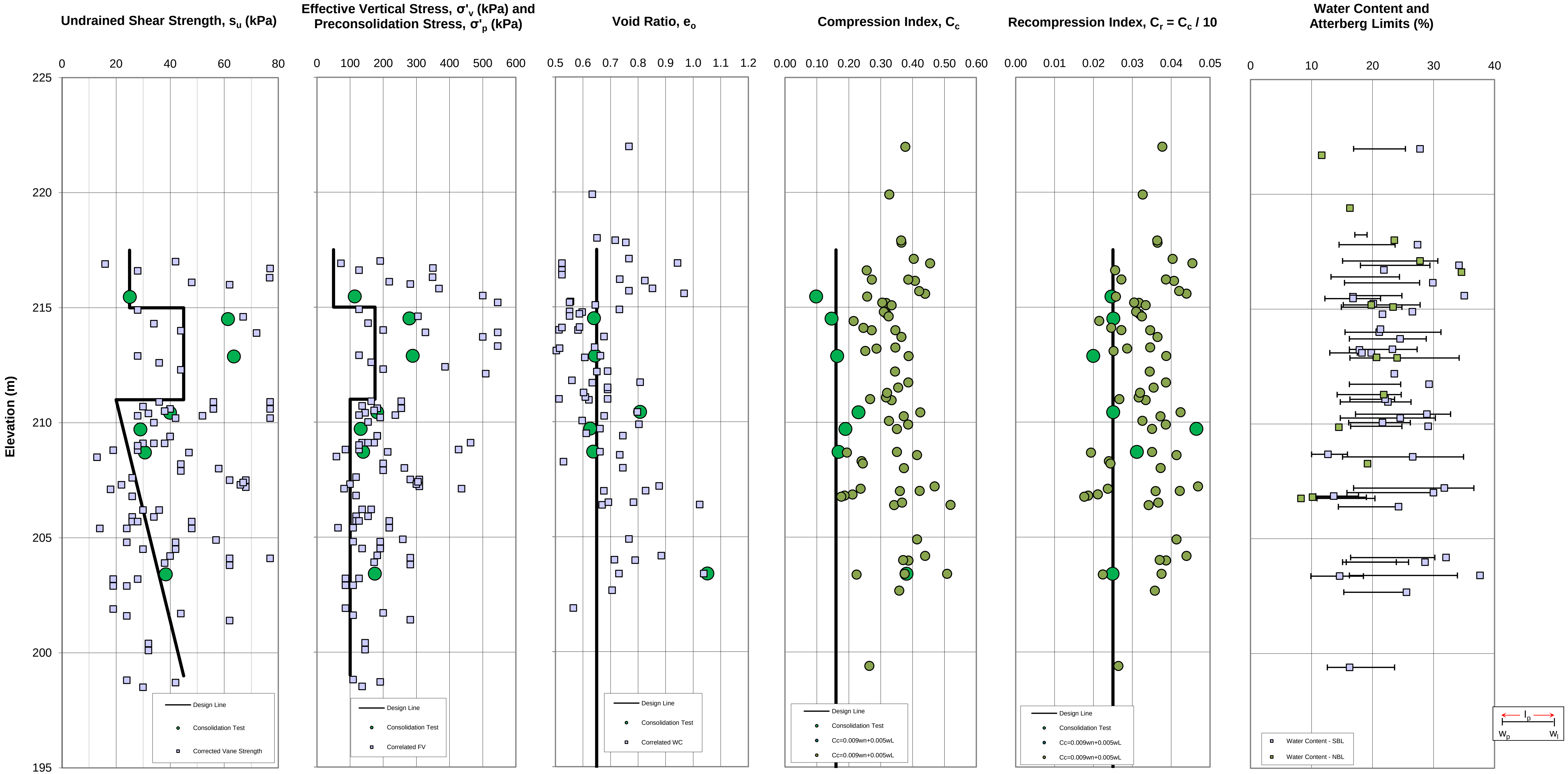
Project No: 09-1111-0018

Analysis By: TWB **Reviewed By:** SMM

\\golder.gds\gal\Mississauga\Active\2009\1111\09-1111-0018 URS - HWY 400 - York Region\4 - Analysis & Design\Contract 1 Embankment and RSS\[Copy of 09-1111-0018-South Canal Embankments and Berm-Parameters and Design Lir

SUMMARY PLOT OF ENGINEERING PARAMETERS FOR COHESIVE DEPOSITS
Highway 400 North Embankment at South Canal

FIGURE 6



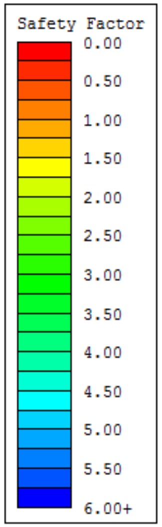
Date: November 2013
Project No: 09-1111-0018

Prepared By: TWB
Checked By: SMM

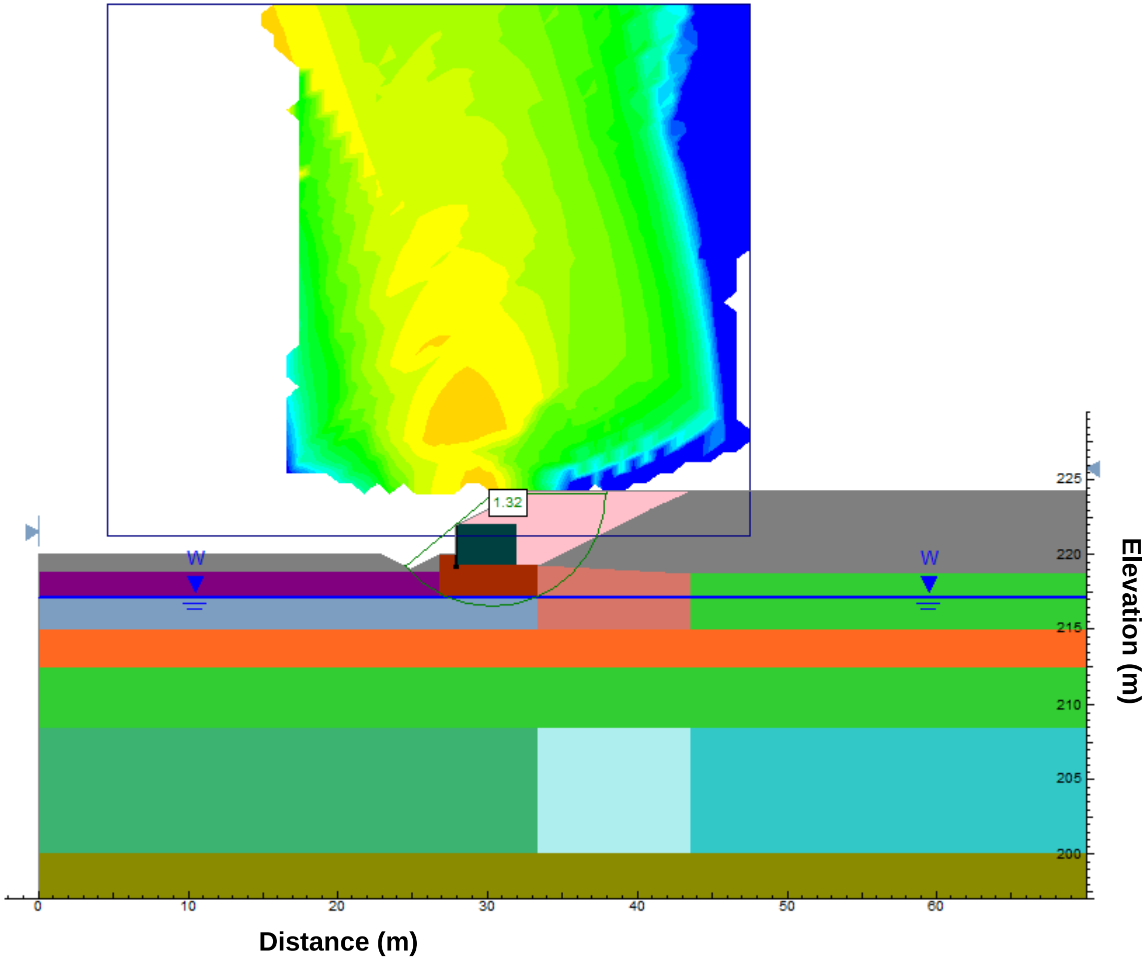
Golder Associates

Static Global Stability – Area 3 Embankment Height <4.2 m with Subexcavation of Existing Peat - Short-Term (Undrained) Conditions

Figure 7



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Existing Embankment	■	21	0	30
Upper Clayey Silt (Outside Embankment)	🟦	19	20	0
Clayey Silt (stiff)	🟩	19	45	0
Lower Clayey Silt (Outside Embankment)	🟩	19	20	
Sand and Silt Till	🟫	21	0	34
Sand and Silt	🟧	20	0	30
Granular Material	⬜	21	0	35
Lower Clayey Silt (Under Embnakment)	🟦	19	45	0
Lower Clayey Silt (Under Slope)	🟦	19	35	0
Peat	🟪	12	1	27
Upper Clayey Silt (Under Slope)	🟥	19	35	0
Replacement Fill (Above Water Table)	🟫	20	0	28
Retaining Wall	⬛	21		
Wall Fill	⬛	21		



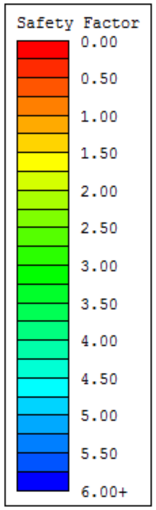
Date: November 2013

Project No: 09-1111-0018

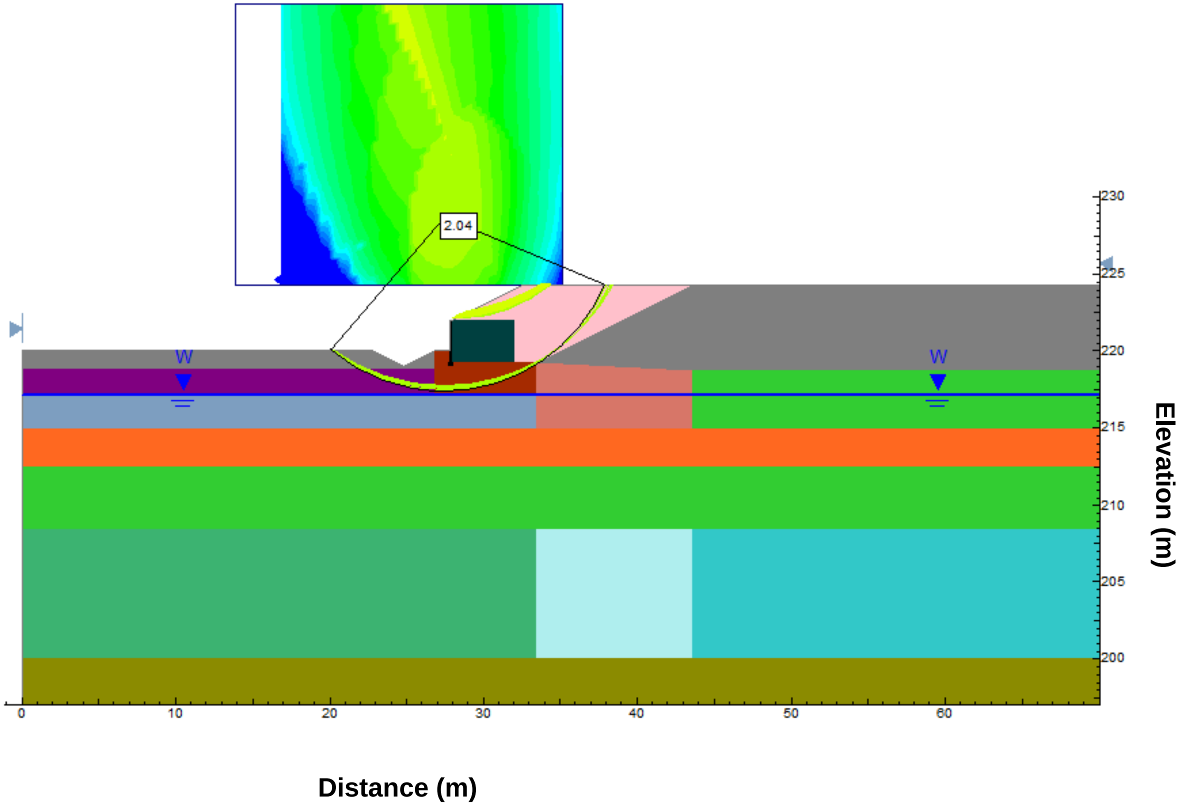
Analysis By: TWB **Reviewed By:** SMM

Static Global Stability – Area 3 Embankment Height <4.2 m with Subexcavation of Existing Peat - Long-Term (Drained) Conditions

Figure 8



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Existing Embankment	⬜	21	0	30
Upper Clayey Silt (Outside Embankment)	🟦	19	0	30
Clayey Silt (stiff)	🟩	19	0	30
Lower Clayey Silt (Outside Embankment)	🟩	19	0	30
Sand and Silt Till	🟫	21	0	34
Sand and Silt	🟧	20	0	30
Granular Material	🟥	21	0	35
Lower Clayey Silt (Under Embnakment)	🟦	19	0	30
Lower Clayey Silt (Under Slope)	🟦	19	0	30
Peat	🟪	12	1	27
Upper Clayey Silt (Under Slope)	🟥	19	0	30
Replacement Fill (Above Water Table)	🟫	20	0	28
Retaining Wall	⬛	21		
Wall Fill	⬛	21		



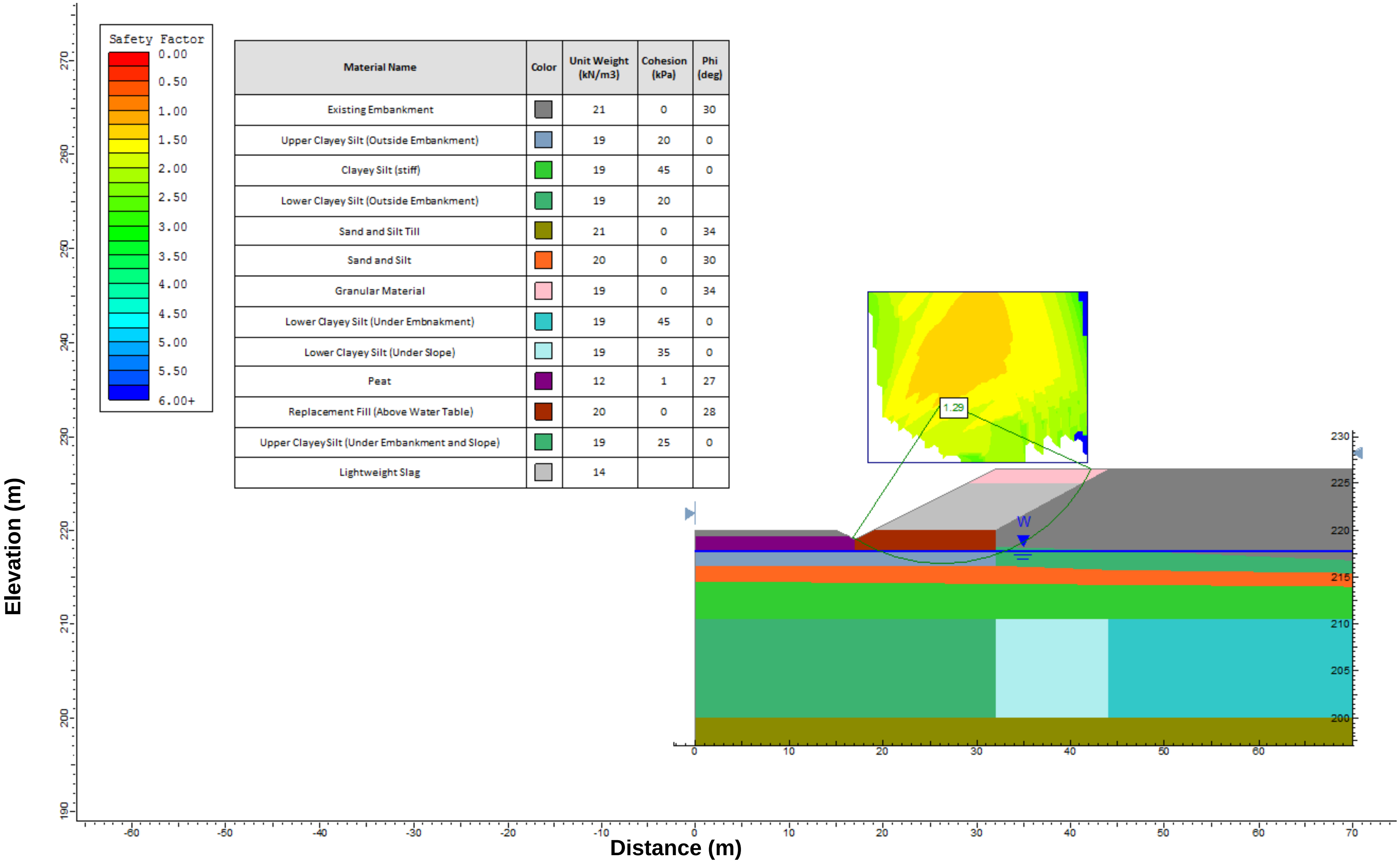
Date: November 2013

Project No: 09-1111-0018

Analysis By: TWB **Reviewed By:** SMM

Static Global Stability – Area 3 Embankment Height > 4.2 m Constructed of Lightweight Slag Fill – Short-Term (Undrained) Conditions

Figure 9



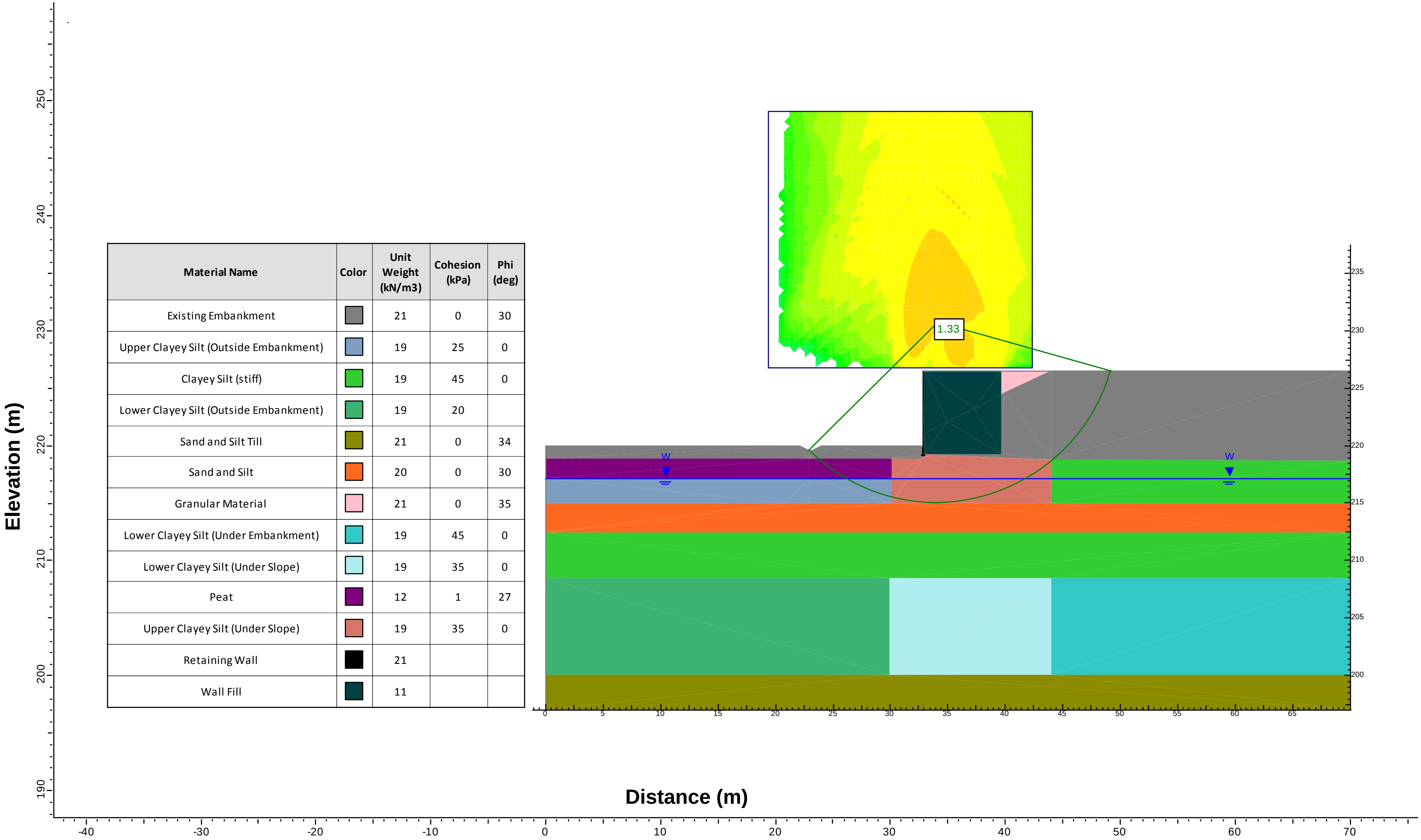
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Existing Embankment	⬛	21	0	30
Upper Clayey Silt (Outside Embankment)	🟦	19	20	0
Clayey Silt (stiff)	🟩	19	45	0
Lower Clayey Silt (Outside Embankment)	🟩	19	20	
Sand and Silt Till	🟫	21	0	34
Sand and Silt	🟧	20	0	30
Granular Material	🟪	19	0	34
Lower Clayey Silt (Under Embnakment)	🟦	19	45	0
Lower Clayey Silt (Under Slope)	🟦	19	35	0
Peat	🟪	12	1	27
Replacement Fill (Above Water Table)	🟥	20	0	28
Upper Clayey Silt (Under Embankment and Slope)	🟩	19	25	0
Lightweight Slag	⬜	14		

Date: November 2013
Project No: 09-1111-0018

Analysis By: TWB **Reviewed By:** SMM

Static Global Stability – Area 4
RSS Wall Constructed of Ultra-Lighweight Slag Fill – Short-Term (Undrained) Conditions

Figure 10



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Existing Embankment	▨	21	0	30
Upper Clayey Silt (Outside Embankment)	🟦	19	25	0
Clayey Silt (stiff)	🟩	19	45	0
Lower Clayey Silt (Outside Embankment)	🟩	19	20	
Sand and Silt Till	🟫	21	0	34
Sand and Silt	🟧	20	0	30
Granular Material	⬜	21	0	35
Lower Clayey Silt (Under Embankment)	🟦	19	45	0
Lower Clayey Silt (Under Slope)	⬜	19	35	0
Peat	🟪	12	1	27
Upper Clayey Silt (Under Slope)	🟥	19	35	0
Retaining Wall	⬛	21		
Wall Fill	⬛	11		

Date: November 2013

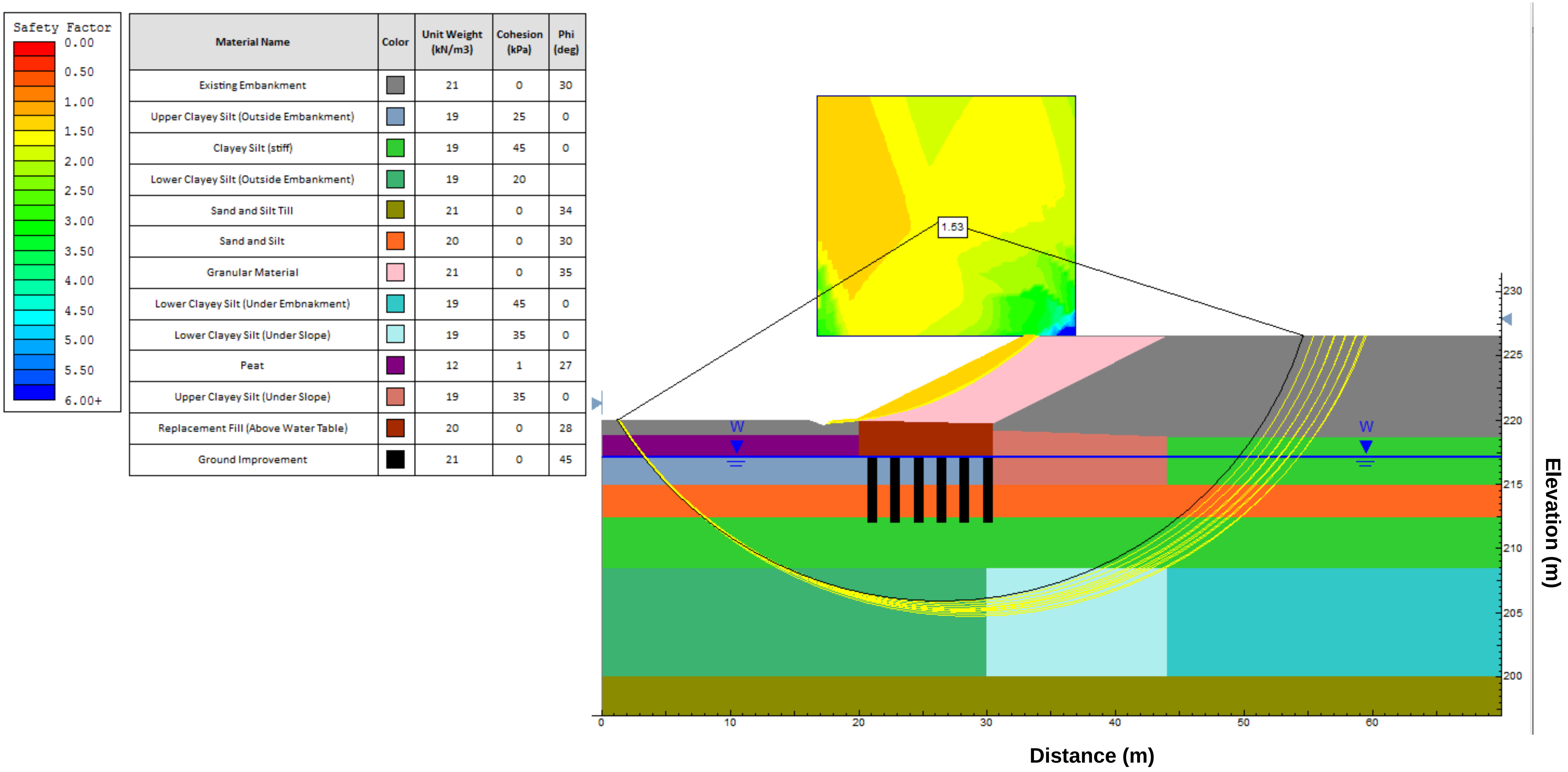
Project No: 09-1111-0018

Analysis By: TWB **Reviewed By:** SMM

Golder Associates

Static Global Stability – Area 3
In Situ Ground Improvement with Conventional Embankment Fill – Short-Term (Undrained) Conditions

Figure 11



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Existing Embankment	◼	21	0	30
Upper Clayey Silt (Outside Embankment)	🟦	19	25	0
Clayey Silt (stiff)	🟩	19	45	0
Lower Clayey Silt (Outside Embankment)	🟩	19	20	
Sand and Silt Till	🟫	21	0	34
Sand and Silt	🟧	20	0	30
Granular Material	⬜	21	0	35
Lower Clayey Silt (Under Embnakment)	🟦	19	45	0
Lower Clayey Silt (Under Slope)	⬜	19	35	0
Peat	🟪	12	1	27
Upper Clayey Silt (Under Slope)	🟥	19	35	0
Replacement Fill (Above Water Table)	🟥	20	0	28
Ground Improvement	⬛	21	0	45

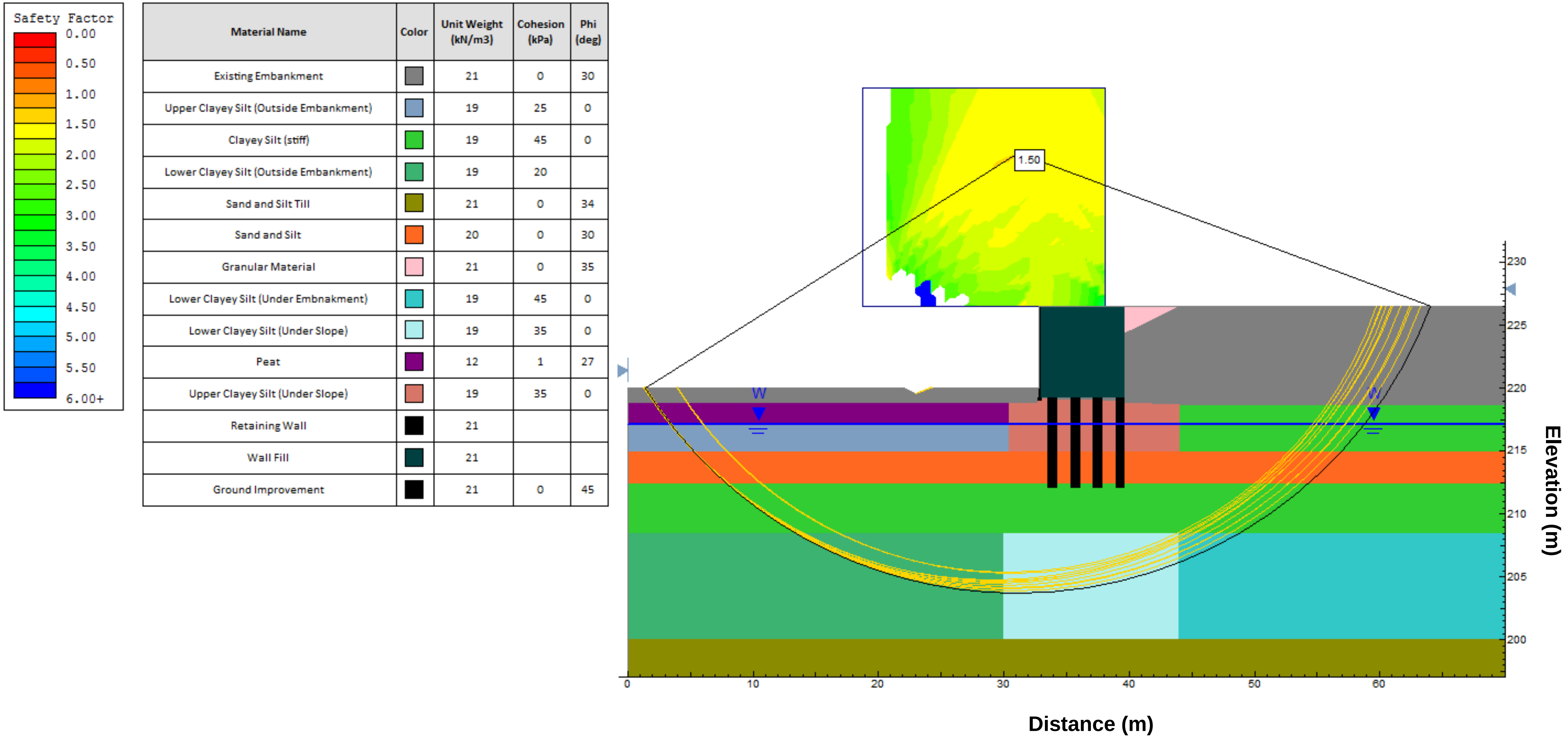
Date: November 2013

Project No: 09-1111-0018

Analysis By: TWB **Reviewed By:** SMM

Static Global Stability – Area 4
In Situ Ground Improvement for Conventional RSS Wall – Short-Term (Undrained) Conditions

Figure 12



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Existing Embankment	⬛	21	0	30
Upper Clayey Silt (Outside Embankment)	🟦	19	25	0
Clayey Silt (stiff)	🟩	19	45	0
Lower Clayey Silt (Outside Embankment)	🟩	19	20	
Sand and Silt Till	🟫	21	0	34
Sand and Silt	🟧	20	0	30
Granular Material	⬜	21	0	35
Lower Clayey Silt (Under Embnakment)	🟦	19	45	0
Lower Clayey Silt (Under Slope)	⬜	19	35	0
Peat	🟪	12	1	27
Upper Clayey Silt (Under Slope)	🟥	19	35	0
Retaining Wall	⬛	21		
Wall Fill	⬛	21		
Ground Improvement	⬛	21	0	45

Date: November 2013

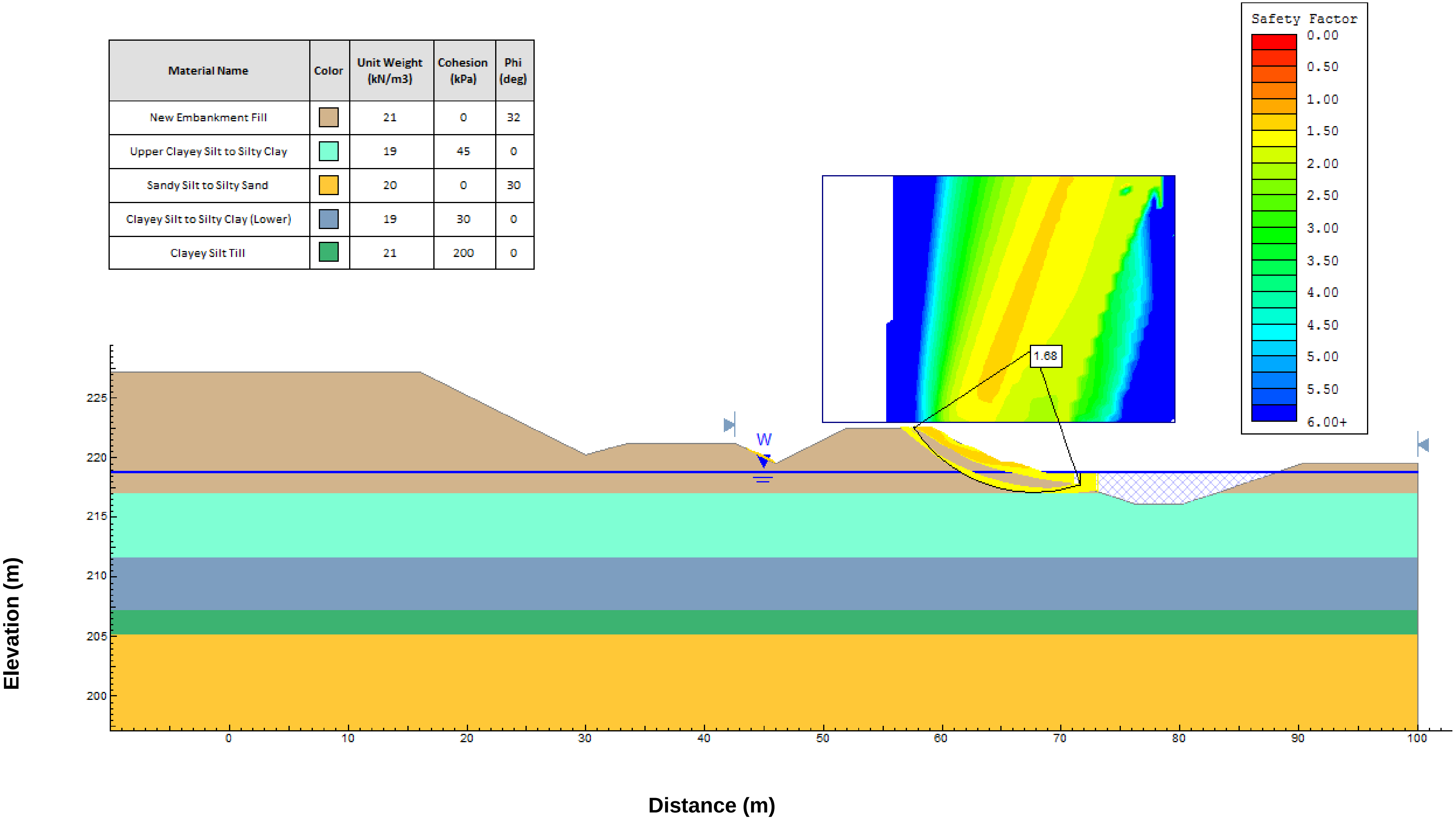
Project No: 09-1111-0018

Analysis By: TWB **Reviewed By:** SMM

Golder Associates

Static Global Stability – South Canal Berm with Organic Soils Removed – Short-Term (Undrained) Conditions

Figure 13



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
New Embankment Fill	🟫	21	0	32
Upper Clayey Silt to Silty Clay	🟩	19	45	0
Sandy Silt to Silty Sand	🟨	20	0	30
Clayey Silt to Silty Clay (Lower)	🟦	19	30	0
Clayey Silt Till	🟩	21	200	0

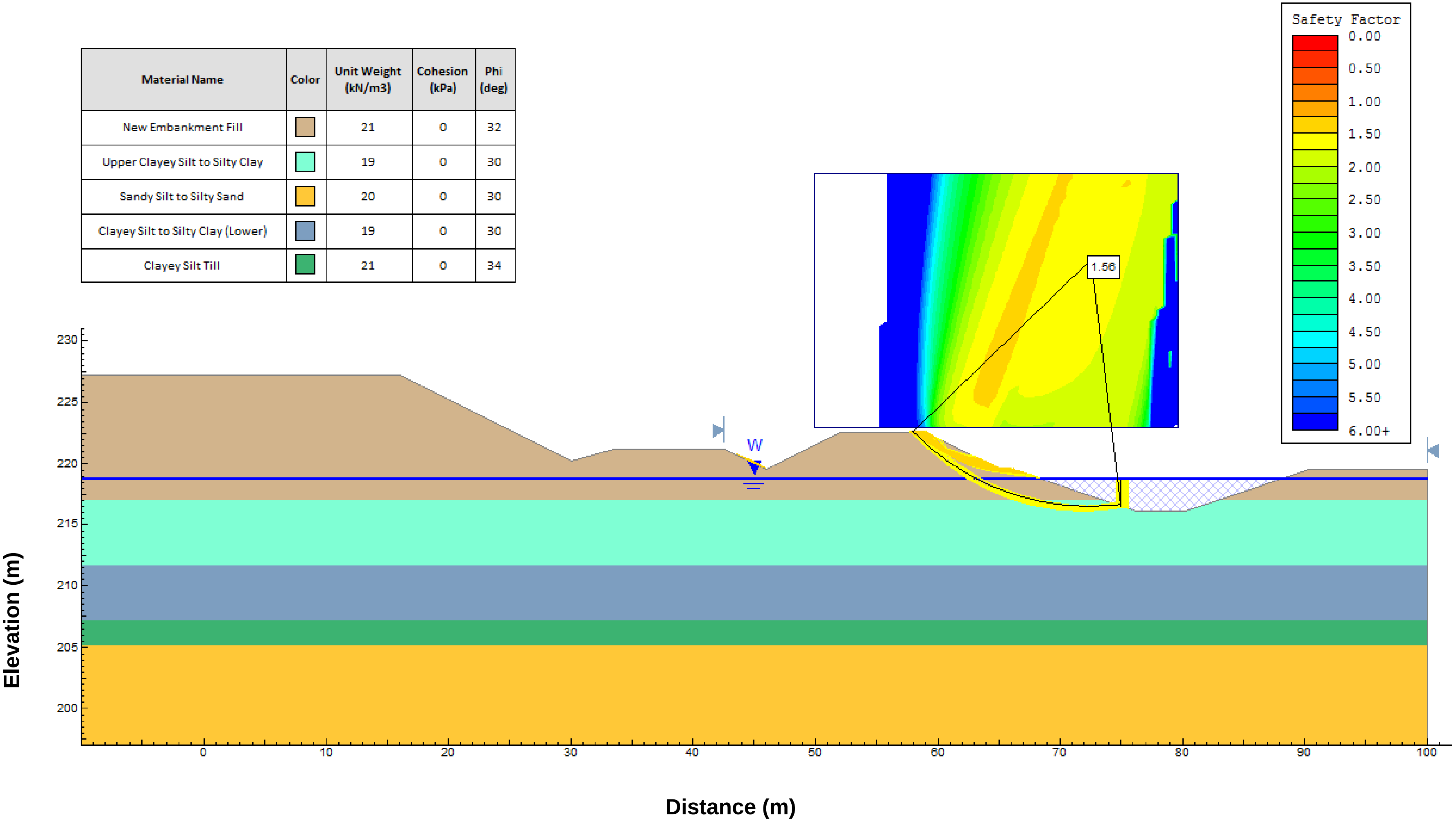
Date: November 2013

Project No: 09-1111-0018

Analysis By: TWB **Reviewed By:** SMM

Static Global Stability – South Canal Berm with Organic Soils Removed – Long-Term (Drained) Conditions

Figure 14



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
New Embankment Fill	🟫	21	0	32
Upper Clayey Silt to Silty Clay	🟦	19	0	30
Sandy Silt to Silty Sand	🟨	20	0	30
Clayey Silt to Silty Clay (Lower)	🟦	19	0	30
Clayey Silt Till	🟩	21	0	34

Date: November 2013

Project No: 09-1111-0018

Analysis By: TWB **Reviewed By:** SMM

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\,\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan\delta$
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan\phi'$

2 shear strength = (compressive strength)/2

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to “A” size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index Relative Density	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency

	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

APPENDIX A

Borehole Records and Laboratory Test Results – Highway 400 Embankment - SBL (Station 24+650 to 24+800) and NBL (Station 24+650 to 24+840)

RECORD OF BOREHOLE No F8-1

SHEET 1 OF 1

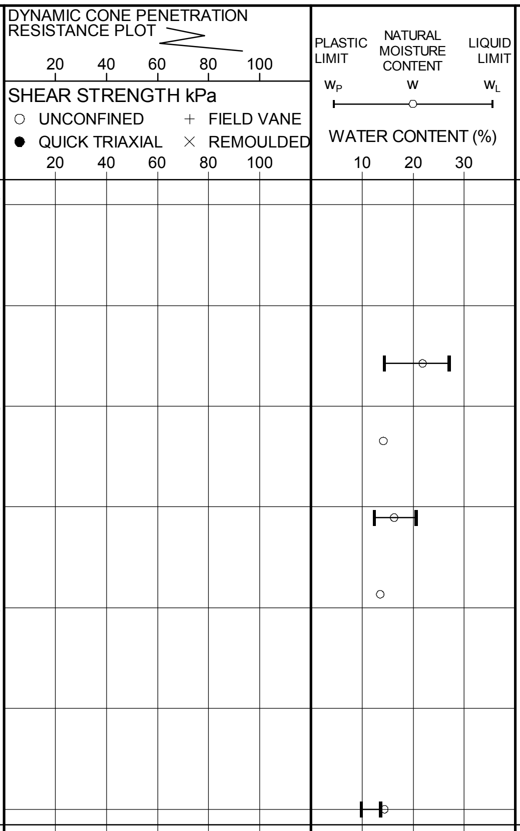
METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
LOCATION N 4877001.3 ;E 297209.6
ORIGINATED BY AM
DIST Central HWY 400
BOREHOLE TYPE D-25 Track Mount, 108 mm Inside Diameter Hollow Stem Augers
COMPILED BY TT
DATUM Geodetic
DATE January 18, 2011
CHECKED BY SMM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
227.3	GROUND SURFACE									
0.0	TOPSOIL									
0.2	Clayey silt, trace to some sand, trace gravel, containing rootlets to a depth of 1.4 m (FILL) Firm to stiff Brown Moist	1	SS	10		227				
		2	SS	8		226				
	Containing sand zones below a depth of 1.5 m	3	SS	13			0	4	67	29
225.1 2.2	CLAYEY SILT, trace sand, trace gravel, containing sandy silt interlayers (TILL) Hard Brown Wet	4	SS	31		225				
		5	SS	31		224				
223.6 3.7	Sandy SILT, trace to some clay, trace gravel (TILL) Very dense Brown Moist	6	SS	111	∇	223	1	29	60	10
		7	SS	138						
222.4 4.9	SILT, trace clay, trace sand, trace gravel, containing zones of silty sand Very Dense Brown to grey Moist Becoming grey at a depth of 5.6 m					222				
		8	SS	127		221				
220.9 6.4	END OF BOREHOLE									

NOTE:

1. Water level in open borehole at a depth of 4.4 m below ground surface (Elev. 222.9 m) upon completion of drilling.



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

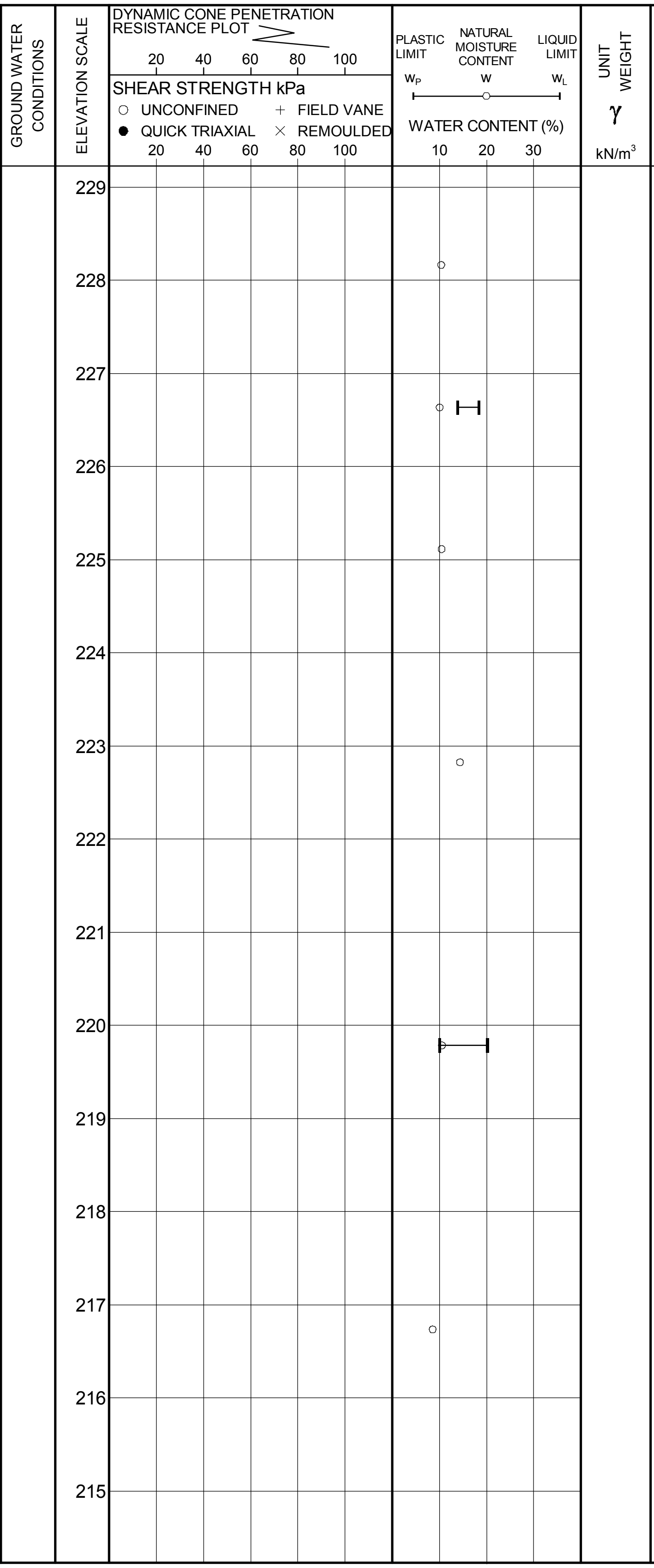
RECORD OF BOREHOLE No F8-2

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877031.6 ;E 297183.6
BOREHOLE TYPE D-90 Track Mount, 108 mm Inside Diameter Hollow Stem Augers
DATE April 1, 2011
ORIGINATED BY AM
COMPILED BY CS
CHECKED BY SMM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
229.2	GROUND SURFACE				
0.0	ASPHALT				
228.9 0.3	Silty sand and gravel (FILL)				
228.4 0.8	Silty sand, trace clay, trace gravel (FILL) Compact Grey Moist	1	SS	21	
227.7 1.5	Clayey silt, some sand, trace to some gravel (FILL) Stiff to very stiff Brown and grey Moist	2	SS	25	
		3	SS	22	
		4	SS	13	
		5	SS	8	3 37 49 11
		6	SS	26	
223.6 5.6	CLAYEY SILT, some sand, trace gravel, slightly organic Very stiff Brown and grey Moist	7	SS	25	O.C. = 1.8 3 17 61 19
222.0 7.2	CLAYEY SILT, trace to some sand, trace gravel (TILL) Stiff to hard Brown Moist	8	SS	9	
		9	SS	32	6 27 47 20
		10	SS	25	
		11	SS	27	
		12	SS	48	



Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No F8-2

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018		
G.W.P. 2835-02-00	LOCATION N 4877031.6 ;E 297183.6	ORIGINATED BY AM
DIST Central HWY 400	BOREHOLE TYPE D-90 Track Mount, 108 mm Inside Diameter Hollow Stem Augers	COMPILED BY CS
DATUM Geodetic	DATE April 1, 2011	CHECKED BY SMM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
213.4	Becoming wet at a depth of 14.8 m Augers grinding at a depth of 15.2 m	▨	13	SS	71	∇	214		○		
15.8	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 15.2 m below ground surface (Elev. 214.0 m) upon completion of drilling.										

$+^{3}, \times^{3}$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No F8-3

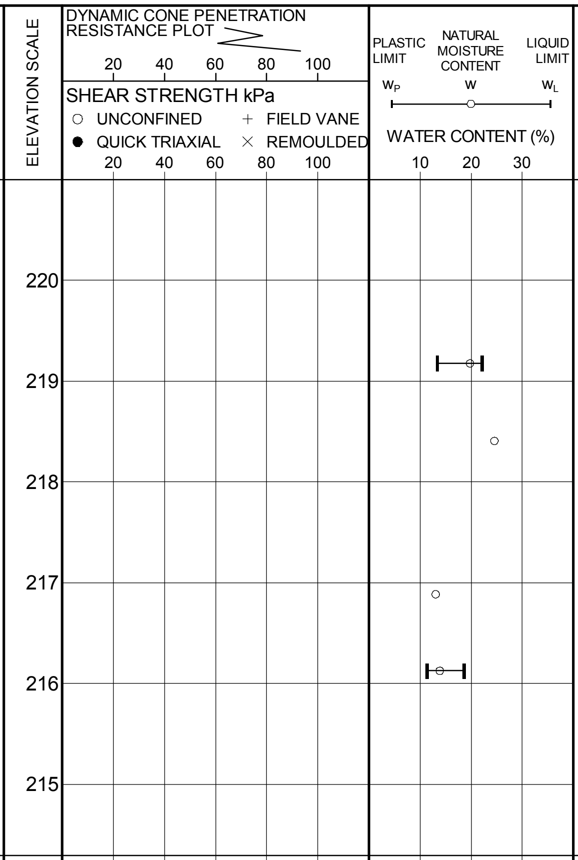
SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877098.8 ;E 297187.5
BOREHOLE TYPE D-25 Track Mount, 108 mm Inside Diameter Hollow Stem Augers
DATE January 18, 2011
ORIGINATED BY AM
COMPILED BY TT
CHECKED BY SMM

ELEV DEPTH	SOIL PROFILE: DESCRIPTION
221.0	GROUND SURFACE
0.0	TOPSOIL
0.2	Clayey silt, trace to some sand, trace gravel, slightly organic, rootlets and wood fragments (FILL) Firm Brown Moist
218.8 2.2	Clayey silt, trace sand (FILL) Stiff Brown Wet Grey clayey silt seams between depths of 2.7 m and 2.8 m
217.7	CLAYEY SILT, trace sand, containing rootlets Stiff Grey Moist
217.3 3.7	CLAYEY SILT with sand (TILL) Very stiff to hard Grey Moist
214.3 6.7	END OF BOREHOLE

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
1	SS	6					
2	SS	4					
3	SS	4					
4	SS	12		0	3	69	28
5	SS	8	∇				
6	SS	16					
7	SS	18		0	26	53	21
8	SS	57					



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTE:

1. Water level in open borehole at a depth of 3.2 m below ground surface (Elev. 217.8 m) upon completion of drilling.

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No F8-4

SHEET 1 OF 1

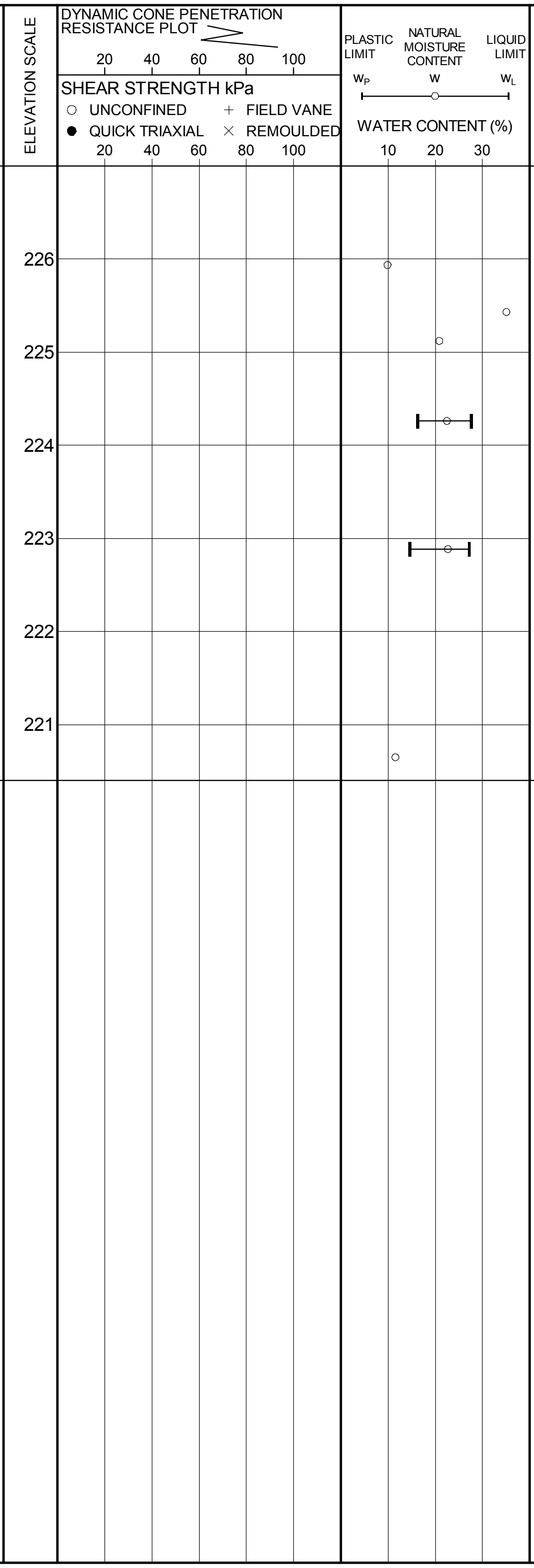
METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4876920.8 ;E 297144.9
BOREHOLE TYPE Geoprobe, 108 mm Outside Diameter Solid Stem Auger
DATE April 4, 2011
ORIGINATED BY TT
COMPILED BY CS
CHECKED BY SMM

SOIL PROFILE		SAMPLES								
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
227.0	GROUND SURFACE									
0.0	TOPSOIL									
0.2	Sand, trace clay, trace gravel (FILL) Compact Brown Moist	1	SS	20						
226.4 0.6	Clayey silt, some sand, trace gravel, containing rootlets, slightly organic (FILL) Stiff Brown and grey Moist	2	SS	11						
225.6	Organic clayey silt (FILL) Black Moist	3A 3B	SS	5			O.C. = 9.1			
1.6	CLAYEY SILT, some sand, trace gravel, containing grey silty sand seams Firm to very stiff Brown Moist	4A 4B	SS	11	∇					
		5	SS	18						
	Becoming grey at a depth of 4.0 m	6	SS	26			0	2	65	33
		7	SS	39						
221.4 5.6	SAND and SILT, trace gravel, trace clay (TILL) Very dense Grey Wet	8	SS	106			2	46	42	10
220.4 6.6	END OF BOREHOLE									

NOTE:

1. Water level in open borehole at a depth of 2.7 m below ground surface (Elev. 224.3 m) upon completion of drilling.



+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No F8-5

SHEET 1 OF 1

METRIC

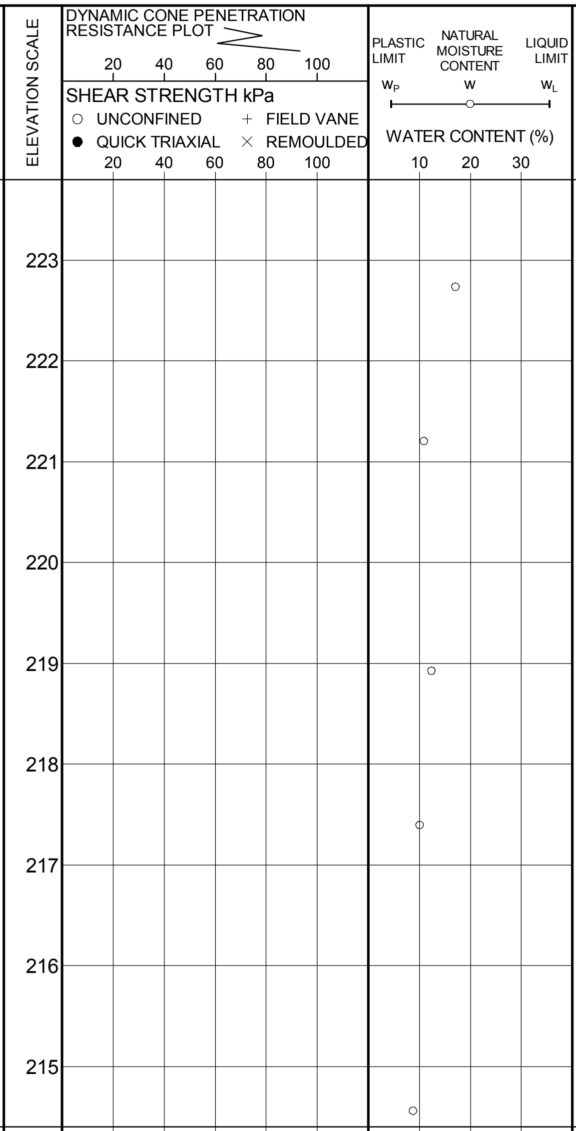
PROJECT 09-1111-0018			
G.W.P. 2835-02-00	LOCATION N 4876957.9 ;E 297131.3	ORIGINATED BY TT
DIST Central HWY 400	BOREHOLE TYPE Geoprobe, 108 mm Outside Diameter Solid Stem Auger	COMPILED BY CS
DATUM Geodetic	DATE April 7, 2011	CHECKED BY SMM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
223.8	GROUND SURFACE								
0.0	Silty sand, trace clay, containing rootlets (FILL) Loose Brown Moist	1	SS	4					
223.1 0.7	Clayey silt, some sand, trace gravel, containing rootlets (FILL) Firm Brown Moist	2	SS	5					
222.3 1.6	PEAT Black Moist	3A 3B	SS	13	▽				
	SAND and SILT, trace to some clay, trace gravel, containing zones of sand, clayey silt and gravelly sand Compact Grey Moist	4	SS	25		8	41	39	12
		5	SS	25					
219.9 3.9	Silty SAND to Sandy SILT, trace to some gravel, trace clay (TILL) Dense to very dense Grey Moist Augers grinding at a depth of 4.4 m	6	SS	40					
		7	SS	58		15	55	25	5
	Augers grinding at a depth of 5.5 m								
		8	SS	98					
		9	SS	100/.18					
214.4		10	SS	100/.10					
9.4	END OF BOREHOLE								

NOTE:

1. Water level in open borehole at a depth of 1.6 m below ground surface (Elev. 222.2 m) upon completion of drilling.

2. Open borehole caved at a depth of 2.3 m below ground surface (Elev. 221.5 m) upon completion of drilling.



+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No F8-6

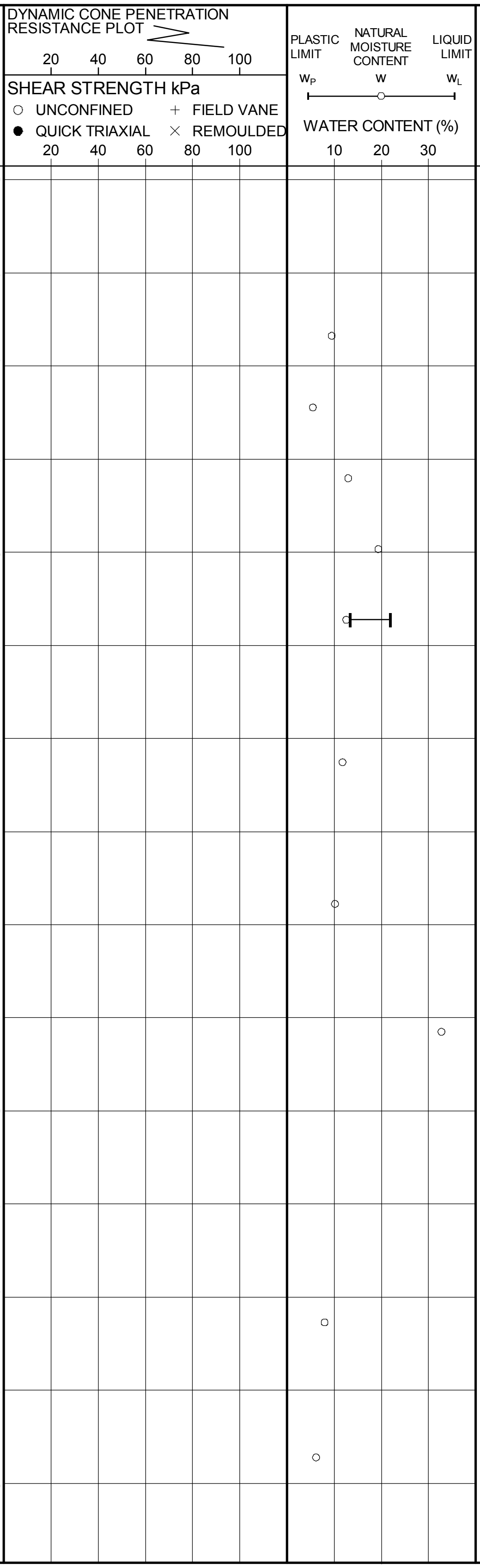
SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877028.4 ;E 297140.7
BOREHOLE TYPE D-90 Truck Mount, 108 mm Inside Diameter Hollow Stem Auger
DATE March 31, 2011
ORIGINATED BY AM
COMPILED BY CS
CHECKED BY SMM

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION
229.1	GROUND SURFACE
0.0	ASPHALT
0.1	Silty sand and gravel (FILL)
228.3 0.8	Clayey silt, some sand, trace gravel (FILL) Stiff Brown Moist
227.6 1.5	Sand and gravel, some silt, trace clay (FILL) Compact Brown Moist
226.1 3.0	Clayey silt, trace sand, trace gravel (FILL) Firm to very stiff Brown to grey Moist Augers grinding and spoon bouncing at a depth of 3.3 m Silt and sand interlayers at a depth of 7.9 m
220.4 8.7	Organic Sandy SILT, some clay, trace gravel Stiff Brown to black Moist
219.6 9.5	Sandy SILT to Silty SAND, trace to some clay, trace gravel (TILL) Compact to very dense Grey Moist Augers grinding and spoon bouncing at a depth of 10.7 m

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	10				
2	SS	18				
3	SS	22	40	45	11	4
4	SS	6				
5	SS	8				
6	SS	15	1	17	57	25
7	SS	27				
8	SS	13				
9A 9B	SS	23	O.C. = 7.0 % 10	28	46	16
10	SS					
11	SS	80	0	25	48	27
12	SS	104				



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+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No F8-6

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

LOCATION N 4877028.4 ;E 297140.7

ORIGINATED BY AM

DIST Central HWY 400

BOREHOLE TYPE D-90 Truck Mount, 108 mm Inside Diameter Hollow Stem Auger

COMPILED BY CS

DATUM Geodetic

DATE March 31, 2011

CHECKED BY SMM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION --- *CONTINUED FROM PREVIOUS PAGE* ---	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Sandy SILT to Silty SAND, trace to some clay, trace gravel (TILL) Compact to very dense Grey Moist						214				
			13	SS	104				○		
							213				
211.9			14	SS	103		212		○		
17.2	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 14.9 m below ground surface (Elev. 214.2 m) upon completion of drilling.										

+3, ×3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-1

SHEET 1 OF 2

METRIC

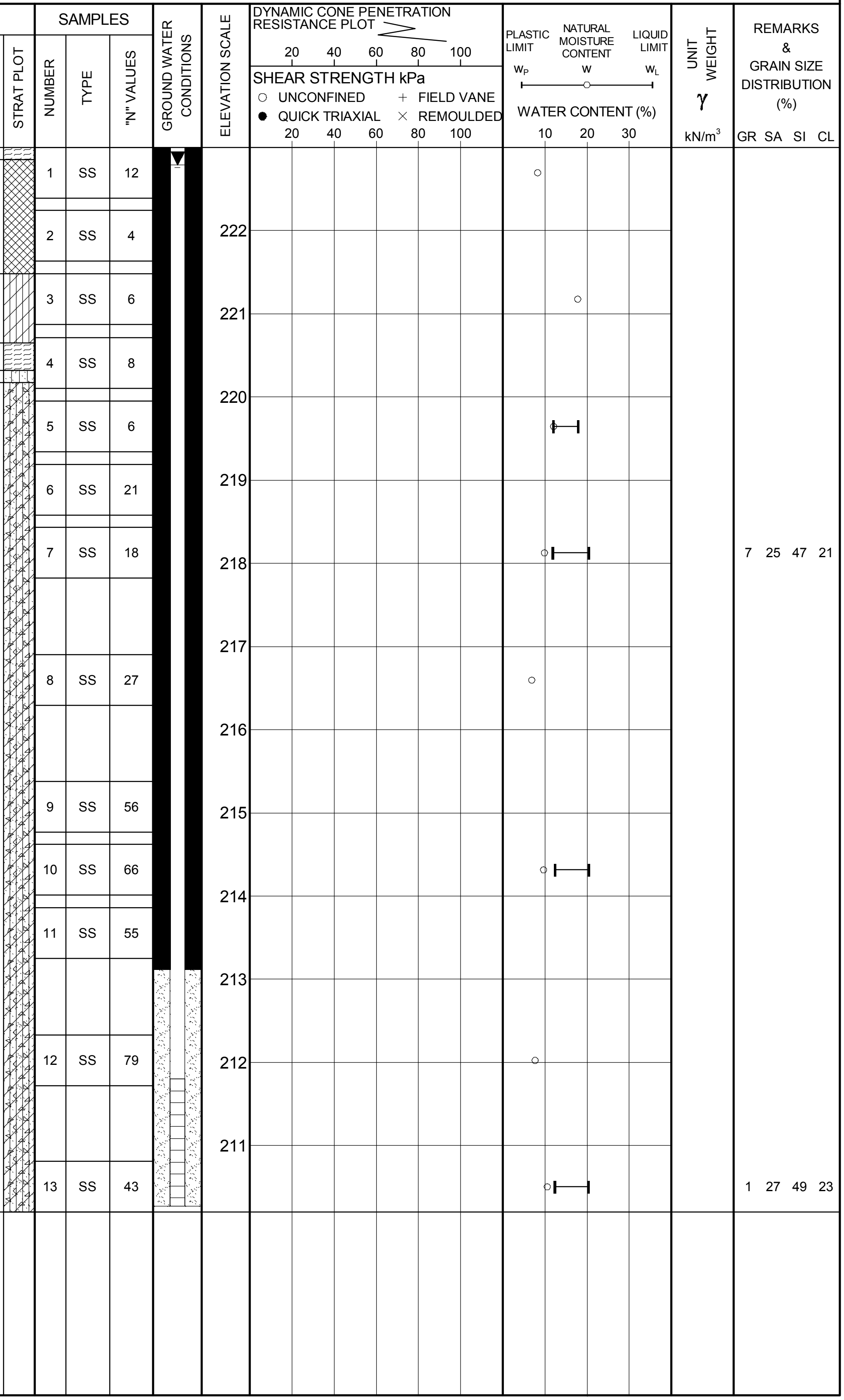
PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877070.0 ;E 297189.1
BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing
DATE June 8 and 11, 2012
ORIGINATED BY OS
COMPILED BY NK
CHECKED BY LCC

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
223.0	GROUND SURFACE
0.0	TOPSOIL
0.2	Silty sand, some gravel, trace clay, containing organic matter and rootlets (FILL) Loose to compact Brown with oxidation staining Moist
221.5 1.5	CLAYEY SILT with sand, trace gravel, containing organic matter Firm Grey and black Moist
220.7	PEAT, containing silt Loose Dark brown to black Moist
220.3 2.8	SILTY SAND, trace clay, trace gravel, containing wood fragments and organic matter Loose Grey and black Moist
	CLAYEY SILT with sand, trace to some gravel (TILL) Firm to hard Grey Moist Cobbles inferred from split spoon bouncing at 7.6 m and 8.4 m
210.2 12.8	

SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	12				
2	SS	4				
3	SS	6				
4	SS	8				
5	SS	6				
6	SS	21				
7	SS	18	7	25	47	21
8	SS	27				
9	SS	56				
10	SS	66				
11	SS	55				
12	SS	79				
13	SS	43	1	27	49	23



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+³, ×³: Numbers refer to Sensitivity

○³% STRAIN AT FAILURE

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PROJECT 09-1111-0018

RECORD OF BOREHOLE No SC-1

SHEET 2 OF 2

METRIC

G.W.P. 2835-02-00
LOCATION N 4877070.0 ;E 297189.1
ORIGINATED BY OS
DIST Central HWY 400
BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing
COMPILED BY NK
DATUM Geodetic
DATE June 8 and 11, 2012
CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION *--- CONTINUED FROM PREVIOUS PAGE ---*	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	END OF BOREHOLE NOTES: 1. Water level in open borehole measured at a depth of 2.8 m (Elev. 220.2 m) on completion of drilling. 2. Water level in piezometer measured at a depth of 0.3 m (Elev. 222.7 m) on June 12, 2012.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-2

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018			
G.W.P. 2835-02-00	LOCATION N 4877082.3 ;E 297188.1		ORIGINATED BY OS
DIST Central	HWY 400	BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing	COMPILED BY NK
DATUM Geodetic		DATE June 6-8, 2012	CHECKED BY LCC

SOIL PROFILE			SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
222.0	GROUND SURFACE								
0.0	TOPSOIL								
0.1	CLAYEY SILT with sand, trace to some gravel, containing wet silty sand lenses Soft to firm Brown to grey below 0.7 m Moist		1	SS	7				
			2	SS	3				
220.3 1.9	PEAT, containing silt Loose Dark brown to black Moist		3	SS	2				
	Sandy SILT, some clay, containing wood fragments and organic matter Very loose to compact Grey Moist to wet		4	SS	15	0	25	60	15
218.9 3.1	CLAYEY SILT with sand, trace to some gravel (TILL) Firm to hard Grey Moist		5	SS	6				
			6	SS	19	9	25	46	20
			7	SS	34				
			8	SS	29				
			9	SS	25				
			10	SS	31				
			11	SS	36				
			12	SS	34				
			13	SS	71				
208.1 13.9	SAND and SILT, trace clay, trace gravel (TILL) Very dense Grey Wet		14	SS	66				

GROUND WATER CONDITIONS

ELEVATION SCALE

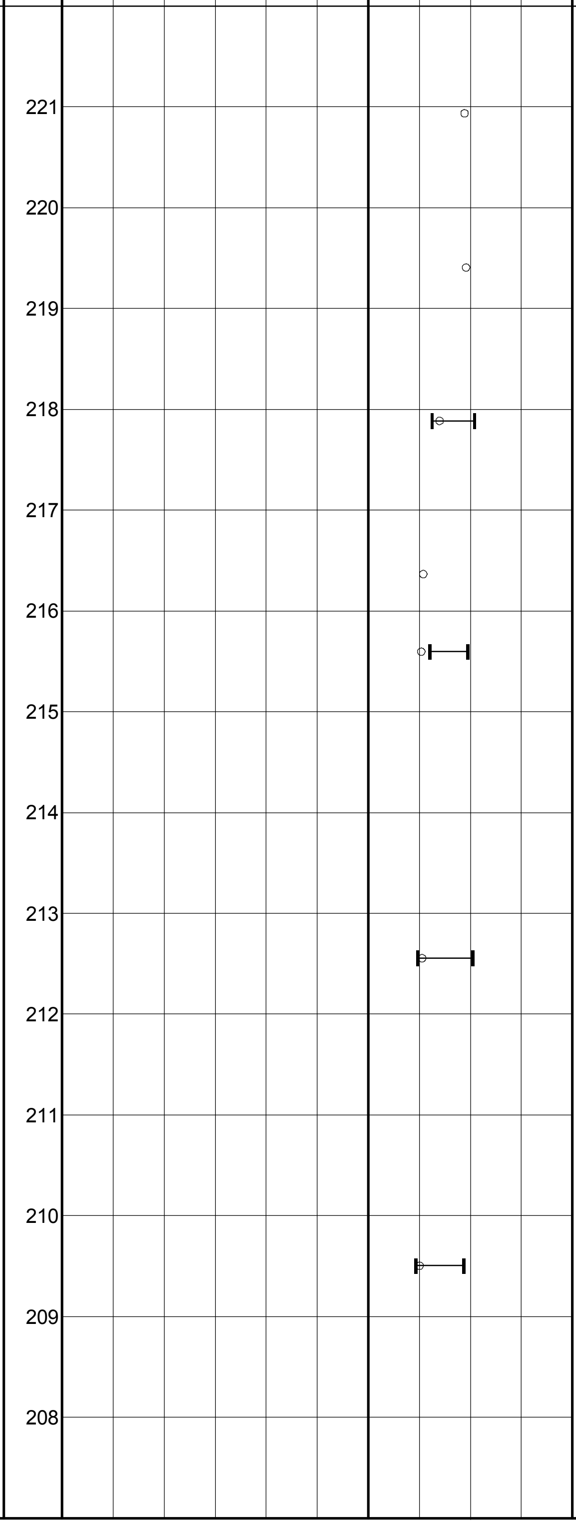
DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m^3



Continued Next Page

+^{3}, ×^{3}: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-2

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4877082.3 ;E 297188.1
BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing
DATE June 6-8, 2012

ORIGINATED BY OS
COMPILED BY NK
CHECKED BY LCC

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---													
	SAND and SILT, trace clay, trace gravel (TILL) Very dense Grey Wet		15	SS	55				○		2	61	30	7
							206							
204.6			16	SS	67		205							
17.4	END OF BOREHOLE NOTES: 1. Artesian conditions observed at a depth of 13.7 m (Elev. 208.3 m) during drilling operations. 2. Water level measured inside casing at 2.0 m above ground surface (Elev. 224.0 m) on completion of drilling. 3. Borehole abandoned using cement grout.													

$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

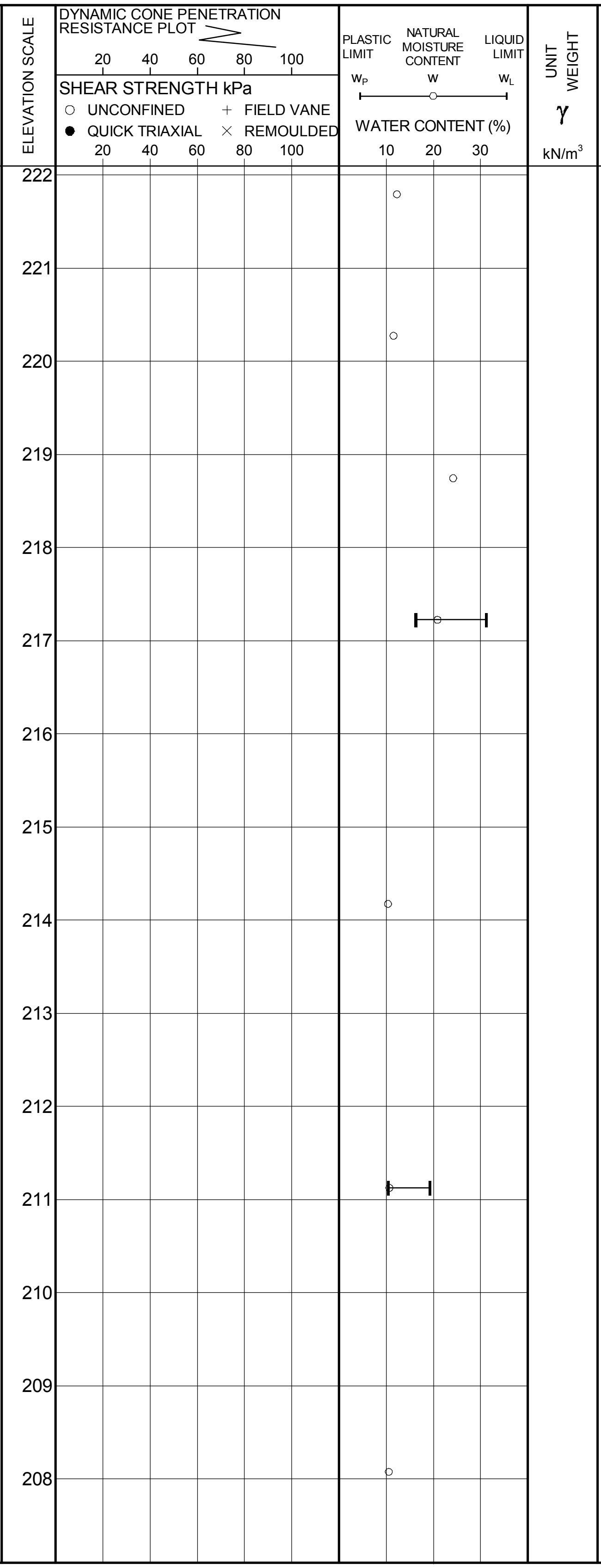
RECORD OF BOREHOLE No SC-10

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877033.5 ;E 297122.5
BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing
DATE May 14,2012
ORIGINATED BY OS
COMPILED BY NK
CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
222.1	GROUND SURFACE								
0.0	TOPSOIL								
0.1	CLAYEY SILT with to some sand, some gravel, containing rootlets and organic matter/wood fragments Firm to very stiff Brown to grey Moist	1	SS	7					
		2	SS	14					
		3	SS	27	∇				
219.9 2.2	PEAT (Fibrous) Stiff Black Moist	4	SS	11					
219.4 2.7	Gravelly SAND and SILT, trace clay, containing clayey silt seams Compact to dense Grey Moist	5	SS	35		25	40	30	5
218.4 3.7	CLAYEY SILT, trace to some gravel, trace to some sand Stiff to very stiff Grey Moist	6	SS	26					
		7	SS	19		0	2	64	34
		8	SS	14					
214.9 7.2	CLAYEY SILT with to some sand, trace gravel (TILL) Hard Grey Moist	9	SS	40					
		10	SS	52					
		11	SS	74		1	25	47	27
		12	SS	110					
		13	SS	105					



REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-10

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4877033.5 ;E 297122.5

BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing

DATE May 14,2012

ORIGINATED BY OS

COMPILED BY NK

CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION --- CONTINUED FROM PREVIOUS PAGE ---	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	CLAYEY SILT with to some sand, trace gravel (TILL) Hard Grey Moist						207				
206.2			14	SS	121						
15.9	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 2.1 m (Elev. 220.0 m) on completion of drilling.										

+³, ×³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No SC-11

SHEET 1 OF 2

METRIC

PROJECT	09-1111-0018		
G.W.P.	2835-02-00	LOCATION	N 4877019.1 ;E 297122.9
DIST	Central HWY 400	BOREHOLE TYPE	D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing
DATUM	Geodetic	DATE	May 11, 2012

ORIGINATED BY OS
COMPILED BY NK
CHECKED BY LCC

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
221.8	GROUND SURFACE
0.0	TOPSOIL
0.1	Sand and gravel, trace clay, some silt, containing rootlets and organic matter (FILL) Loose to compact Dark brown to brown Moist, becoming wet at a depth of 0.3 m
220.4 1.4	Clayey silt with sand (FILL) Firm Brown Moist
219.7	PEAT
	SAND and GRAVEL, containing wood fragments Dense Grey Moist
219.2 2.6	CLAYEY SILT, trace sand, trace gravel Very stiff Grey Moist
218.1 3.7	CLAYEY SILT some to with sand, trace to some gravel (TILL) Very stiff to hard Grey Moist
207.5 14.3	

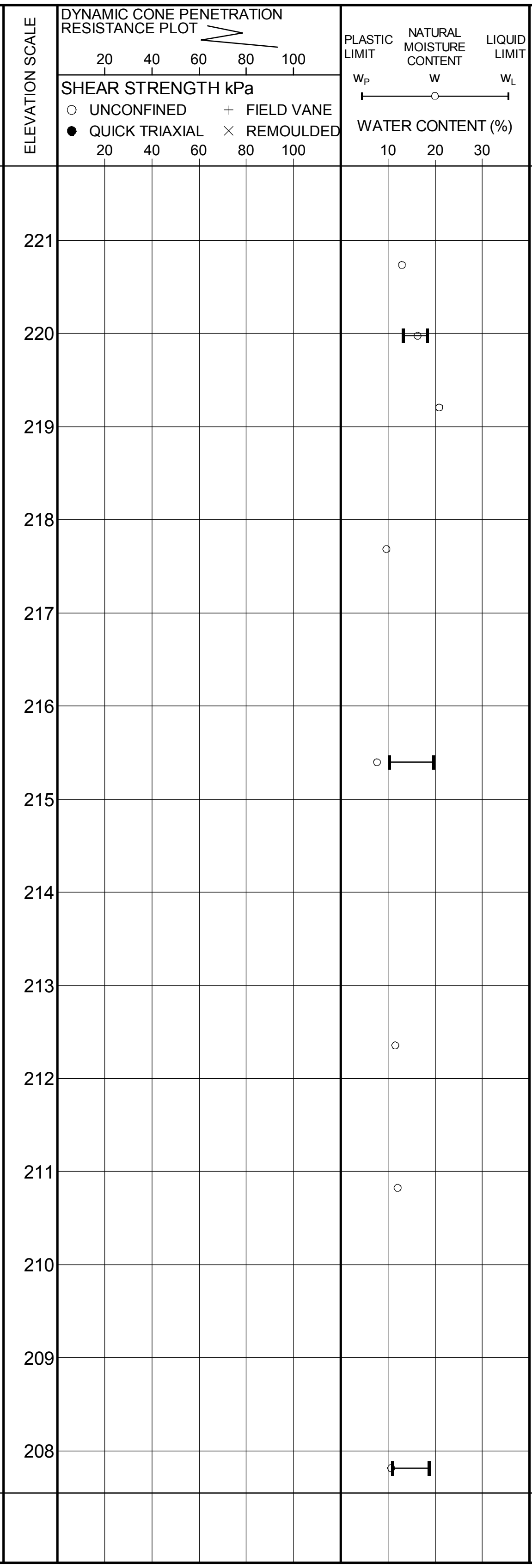
SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	9				
2	SS	15	49	33	13	5
3	SS	7				
4	SS	44				
5	SS	20				
6	SS	46				
7	SS	33				
8	SS	29	19	21	43	17
9	SS	29				
10	SS	29				
11	SS	43				
12	SS	80				
13	SS	106	0	28	47	25

GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)



Continued Next Page

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

PROJECT 09-1111-0018		**RECORD OF BOREHOLE No SC-11**		SHEET 2 OF 2		**METRIC**
G.W.P. 2835-02-00	LOCATION	N 4877019.1 ;E 297122.9			ORIGINATED BY	OS
DIST Central HWY 400	BOREHOLE TYPE	D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing			COMPILED BY	NK
DATUM Geodetic	DATE	May 11, 2012			CHECKED BY	LCC

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION *--- CONTINUED FROM PREVIOUS PAGE ---*	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
	END OF BOREHOLE NOTE: 1. Borehole dry on completion of drilling.										

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-14

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4877041.9 ;E 297120.6

BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing

DATE May 22, 2012

ORIGINATED BY OS

COMPILED BY NK

CHECKED BY LCC

SOIL PROFILE

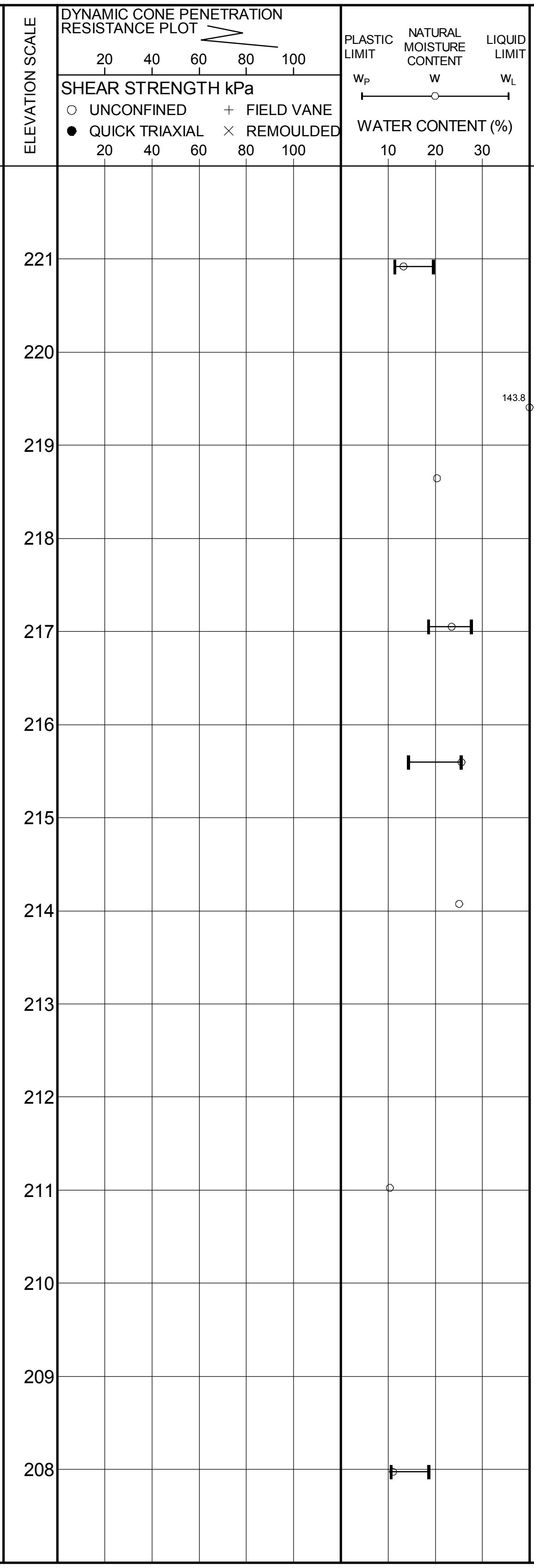
ELEV DEPTH	DESCRIPTION
222.0	GROUND SURFACE
0.0	TOPSOIL
0.2	Silty SAND, some gravel, trace clay, containing rootlets, and organic matter Loose Brown to light brown Moist
221.2 0.8	CLAYEY SILT with sand, some gravel, containing organic matter Very stiff Grey Moist
219.5 2.7	PEAT, containing wood fragments Stiff Black Moist
218.5 3.5	SAND and SILT, trace clay, trace gravel Compact Brown Moist
	CLAYEY SILT, trace sand Stiff to very stiff Light grey to grey, containing oxidized stains Moist to wet
215.3 6.7	CLAYEY SILT with to some sand, trace gravel (TILL) Hard Firm Moist

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	9				
2	SS	19	10	41	37	12
3	SS	17				
4	SS	12				
5	SS	27	5	32	57	6
6	SS	15				
7	SS	19				
8	SS	8				
9	SS	53				
10	SS	48				
11	SS	50				
12	SS	86				
13	SS	63	1	26	47	26

GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³



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+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-14

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018			
G.W.P. 2835-02-00	LOCATION N 4877041.9 ;E 297120.6		ORIGINATED BY OS
DIST Central HWY 400	BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing		COMPILED BY NK
DATUM Geodetic	DATE May 22, 2012		CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- *CONTINUED FROM PREVIOUS PAGE* ---										
	CLAYEY SILT with to some sand, trace gravel (TILL) Hard Firm Moist		14	SS	65						
							206				
			15	SS	72		205				
203.9			16	SS	71		204				
18.1	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 3.7 m (Elev. 218.3 m) on completion of drilling.										

GTA-MTO 001 T:\PROJECTS\2009\09-1111-0018 (URS, YORK REGION)\LOG\0911110018.GPJ GAL-GTA.GDT 01/13/15 SIB

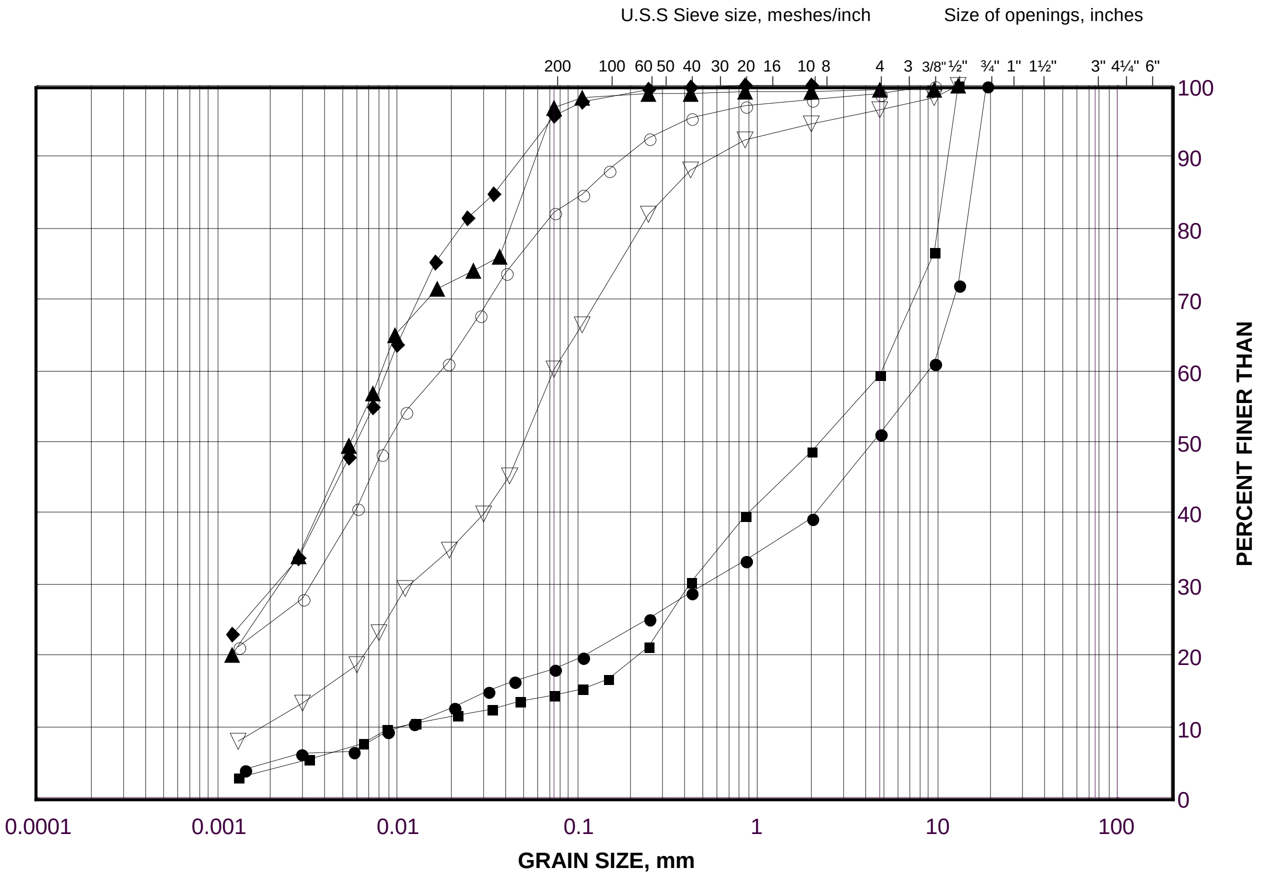
+³, ×³: Numbers refer to Sensitivity

○³% STRAIN AT FAILURE

GRAIN SIZE DISTRIBUTION

Sand and Gravel/Sand and Silt/Clayey Silt (Fill)

FIGURE A1



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-11	2	220.7
■	F8-6	3	226.6
◆	F8-1	3	225.5
▲	F8-3	4	218.4
▽	F8-2	5	225.1
○	F8-6	6	224.2

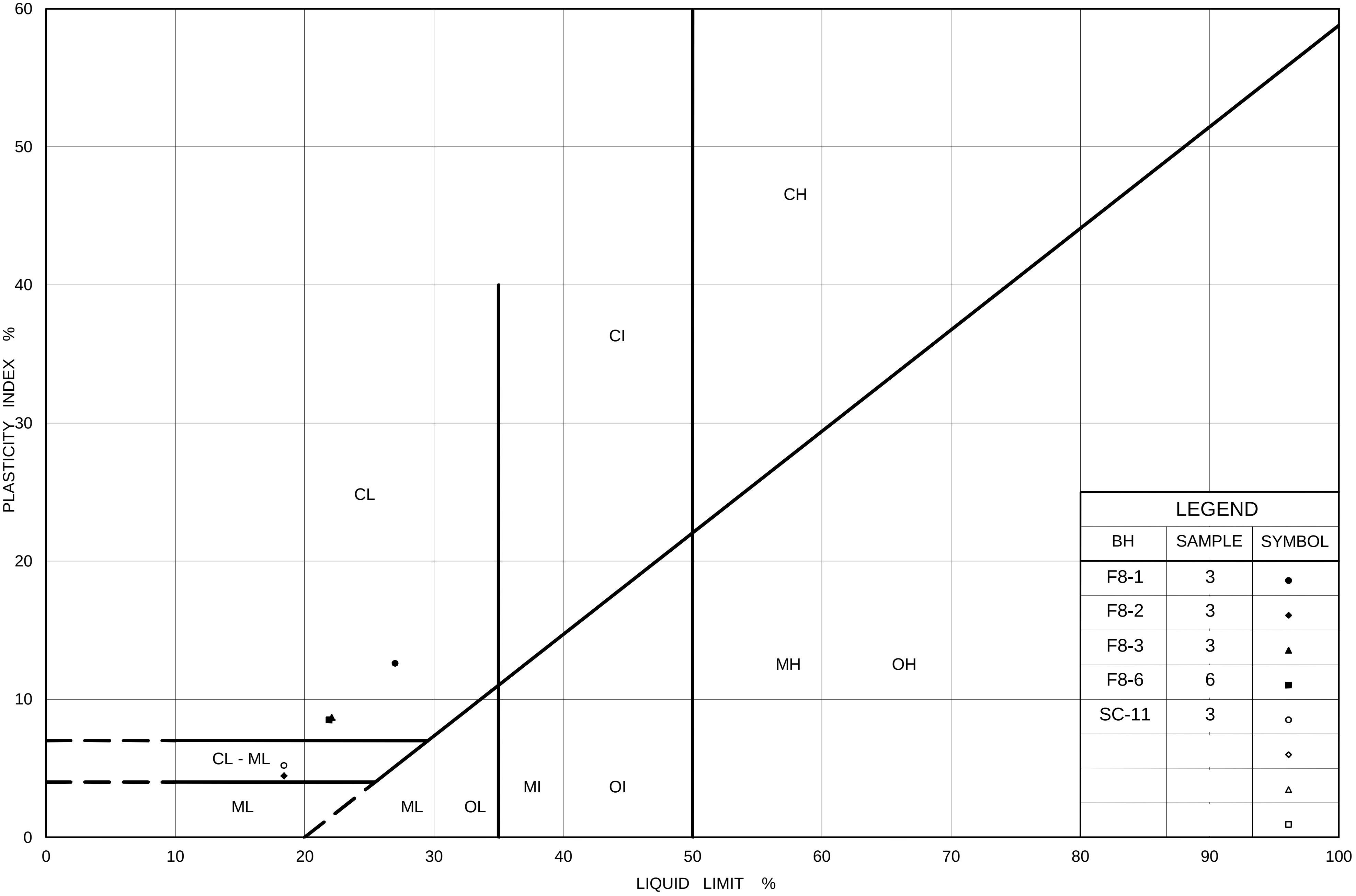
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 10-Jul-13

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt (Fill)

Figure No. A2

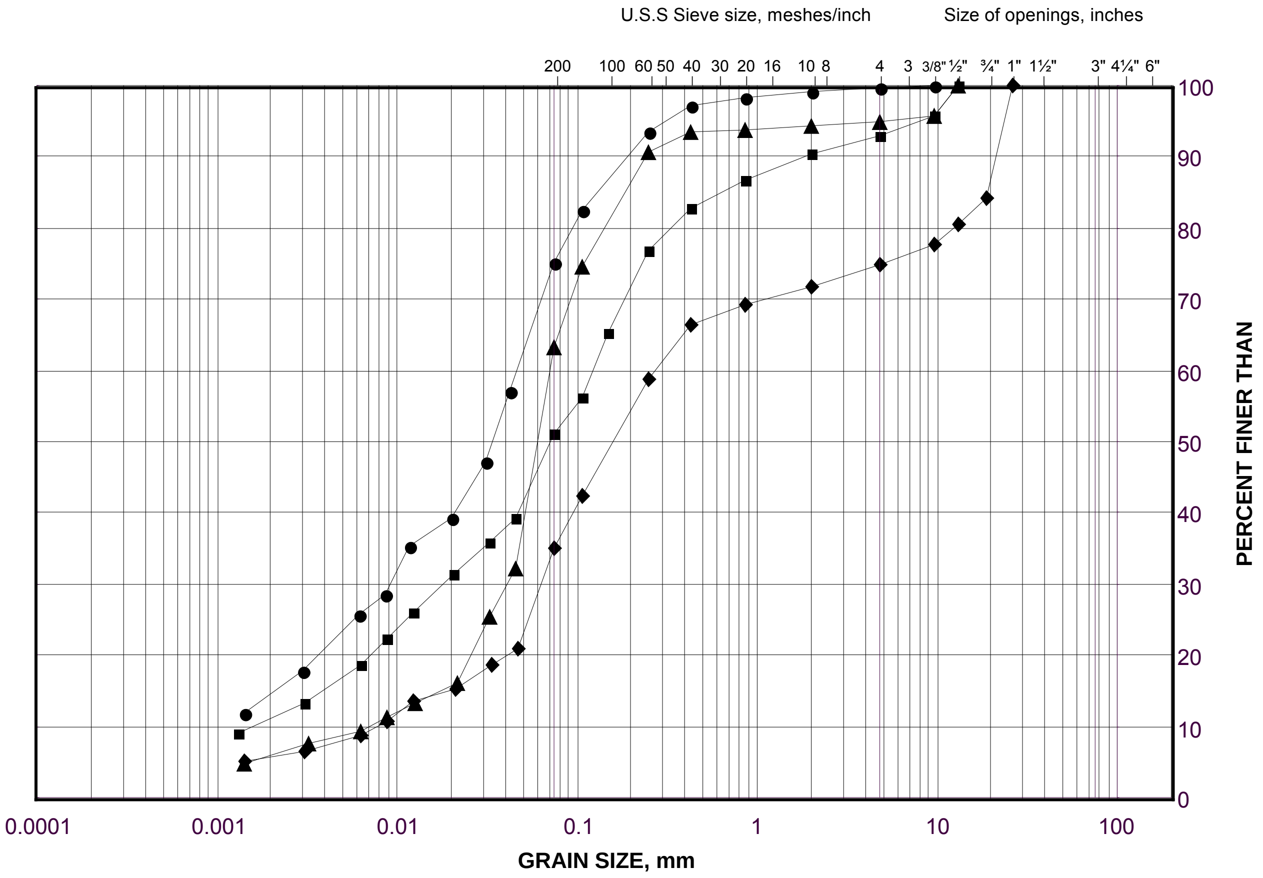
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Sandy Silt to Sand and Silt

FIGURE A3



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-2	4	219.4
■	F8-5	4	221.2
◆	SC-10	5	218.8
▲	SC-14	5A	218.6

Project Number: 09-1111-0018

Checked By: LCC

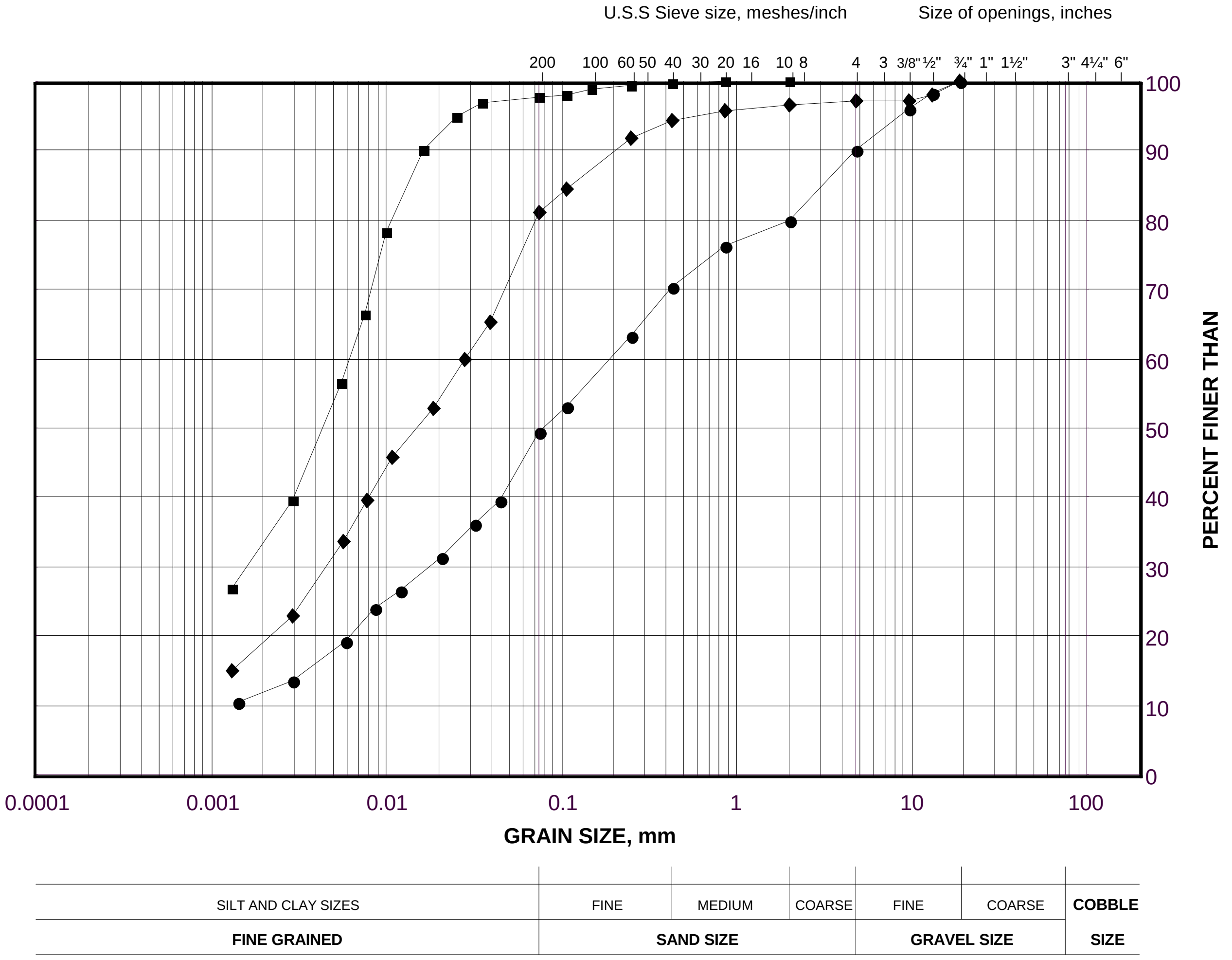
Golder Associates

Date: 10-Jan-13

GRAIN SIZE DISTRIBUTION

Clayey Silt (Upper Deposit)

FIGURE A4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-14	2	220.9
■	F8-4	6	222.9
◆	F8-2	7	222.8

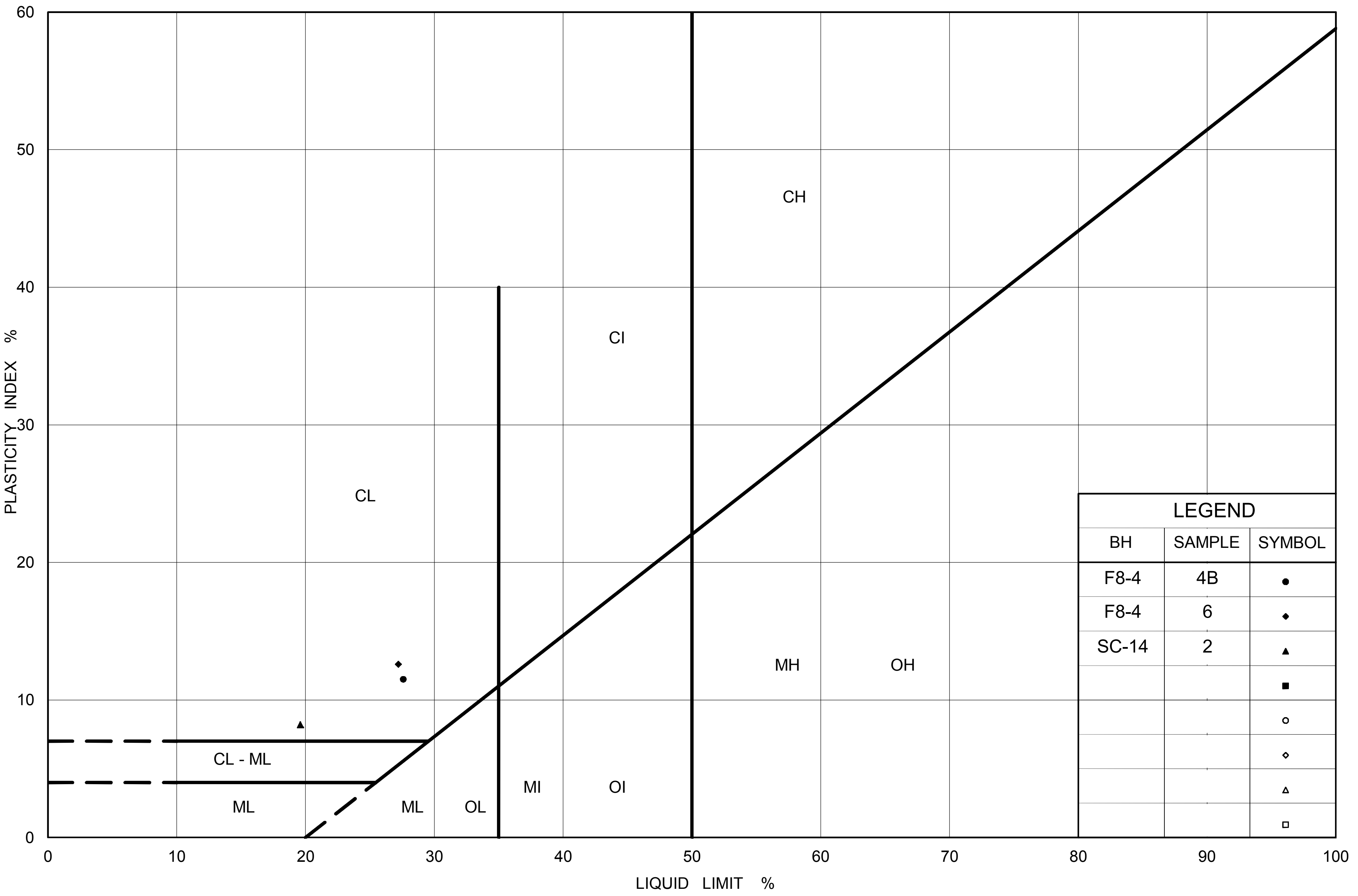
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 10-Jul-13

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt (Upper Deposit)

Figure No. A5

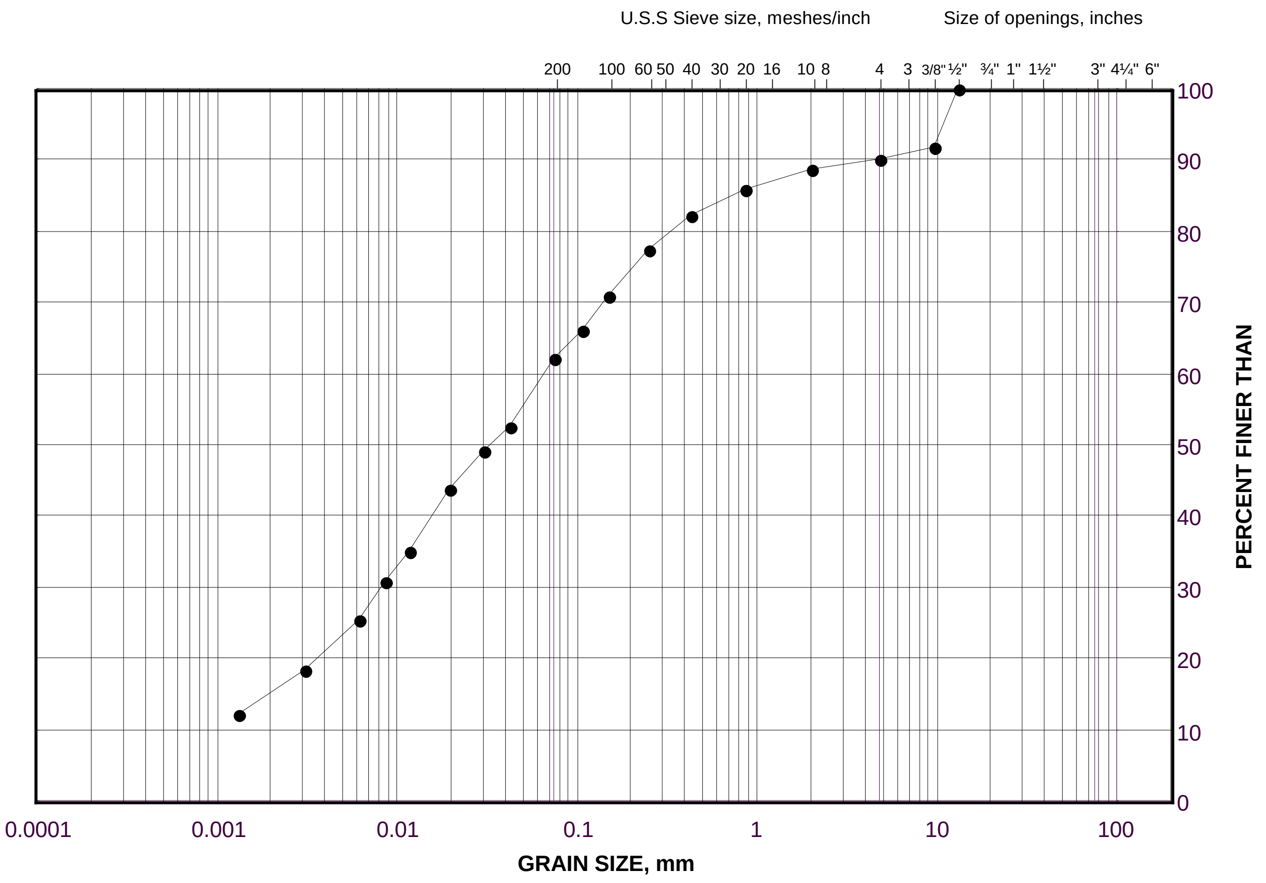
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Organic Sandy Silt

FIGURE A6



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	F8-6	9A	219.8

Project Number: 09-1111-0018

Checked By: LCC

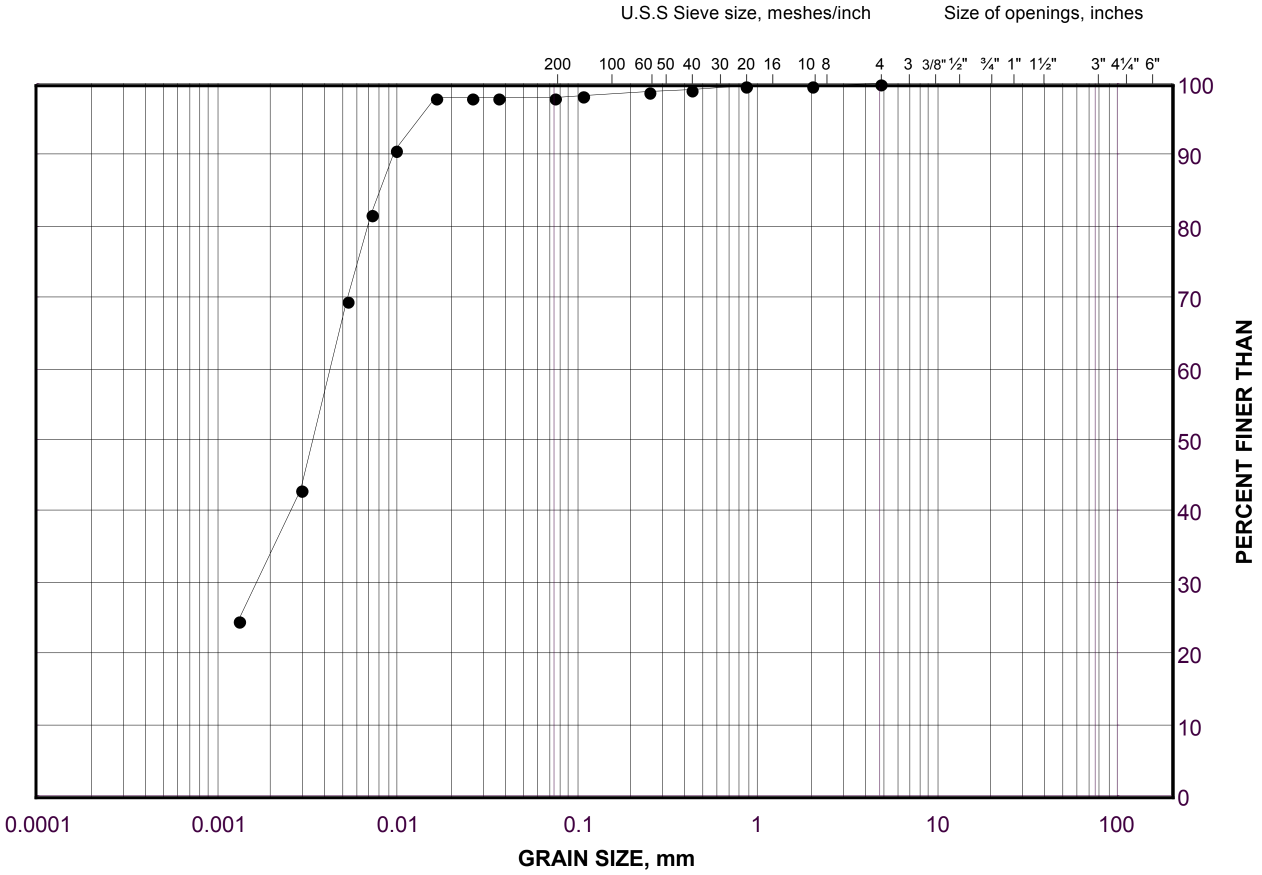
Golder Associates

Date: 10-Jan-13

GRAIN SIZE DISTRIBUTION

Clayey Silt (Lower Deposit)

FIGURE A7



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

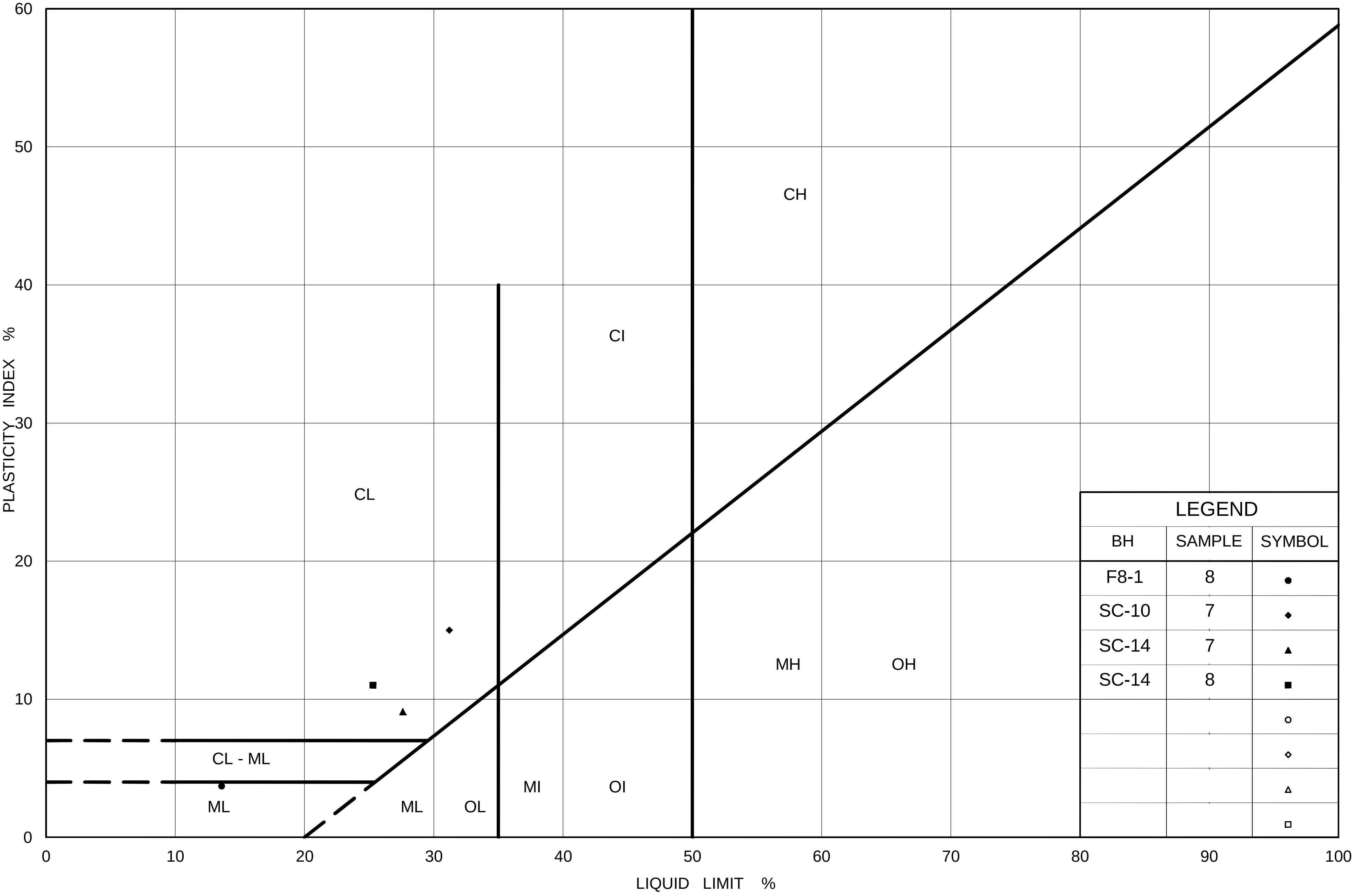
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-10	7	217.2

Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 10-Jan-13



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PLASTICITY CHART
Clayey Silt (Lower Deposit)

Figure No. A8

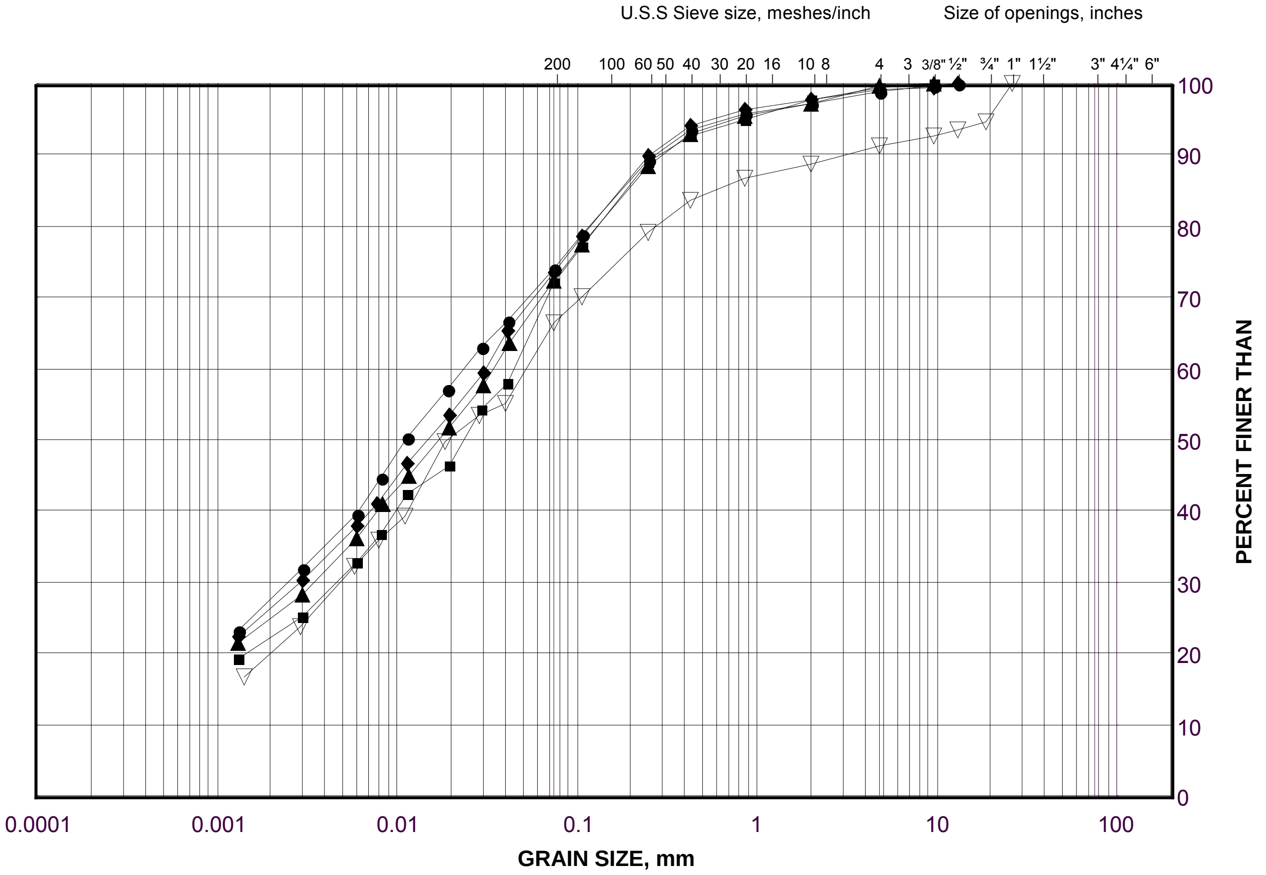
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Clayey Silt (Till)

FIGURE A9A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-10	11	211.1
■	SC-1	13	210.5
◆	SC-14	13	208.0
▲	SC-11	13	207.8
▽	SC-2	6	217.9

Project Number: 09-1111-0018

Checked By: LCC

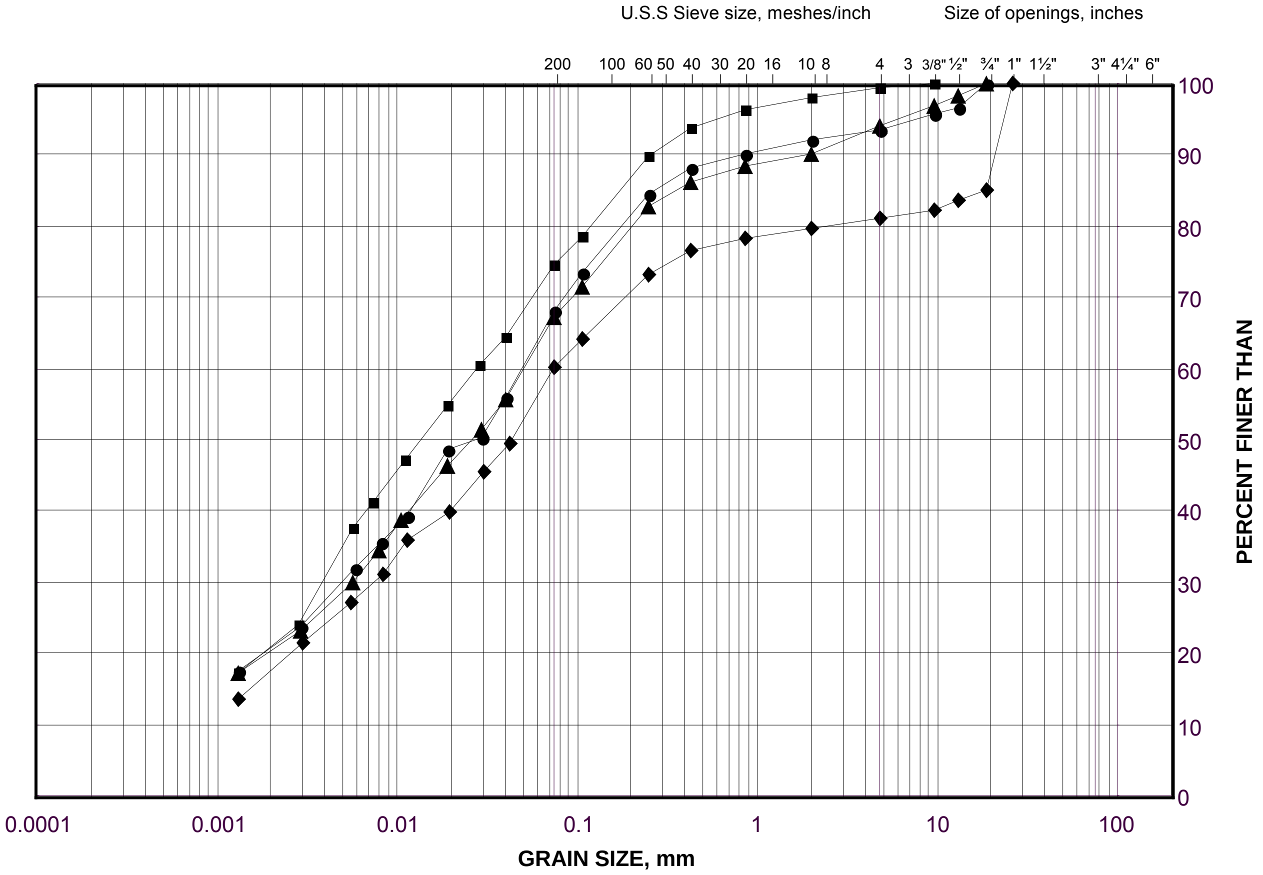
Golder Associates

Date: 10-Jul-13

GRAIN SIZE DISTRIBUTION

Clayey Silt (Till)

FIGURE A9B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-1	7	218.1
■	F8-3	7	216.1
◆	SC-11	8	215.4
▲	F8-2	9	219.8

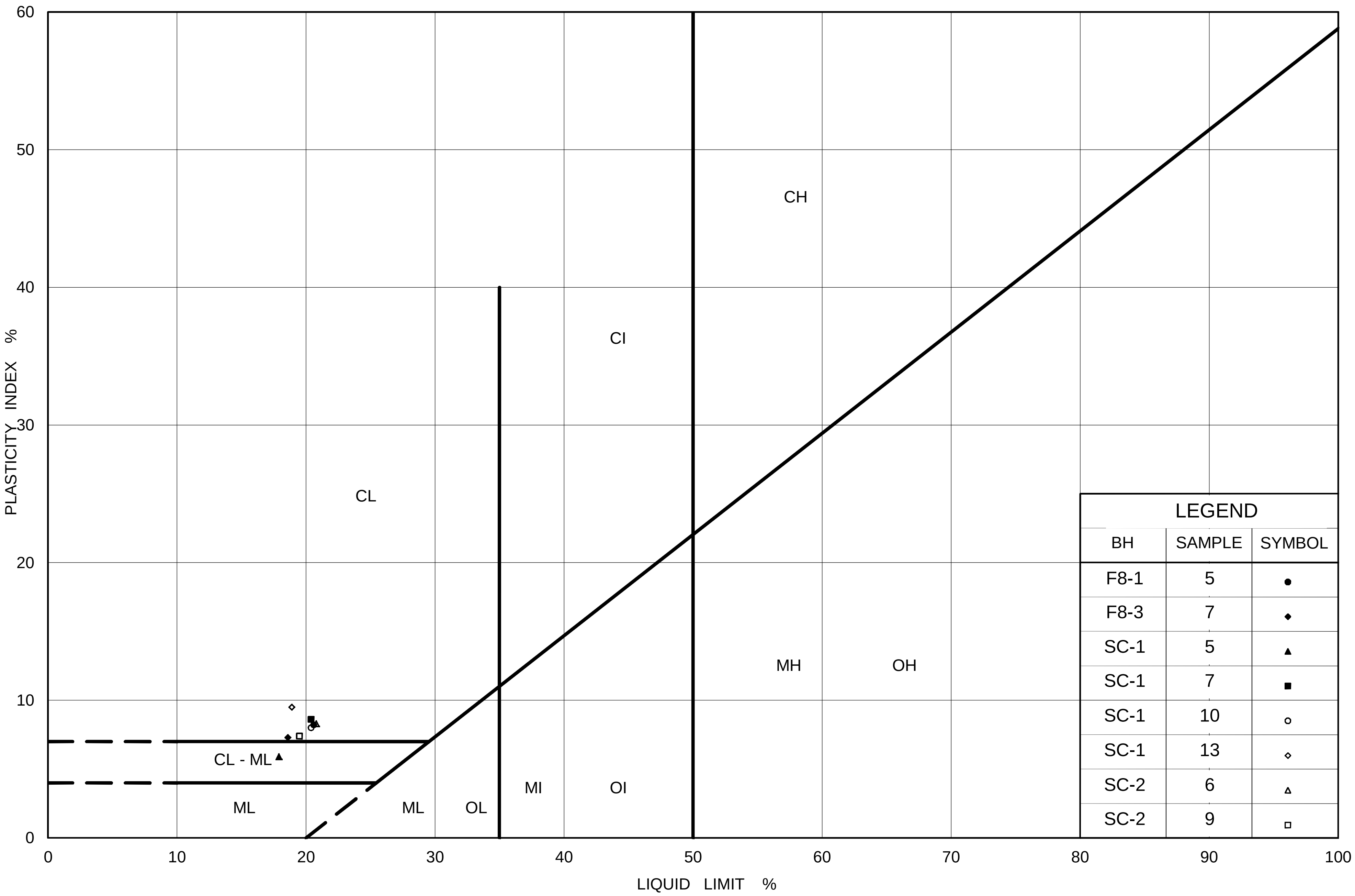
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 10-Jan-13

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
F8-1	5	●
F8-3	7	◆
SC-1	5	▲
SC-1	7	■
SC-1	10	○
SC-1	13	◇
SC-2	6	△
SC-2	9	□

Ministry of Transportation

Ontario

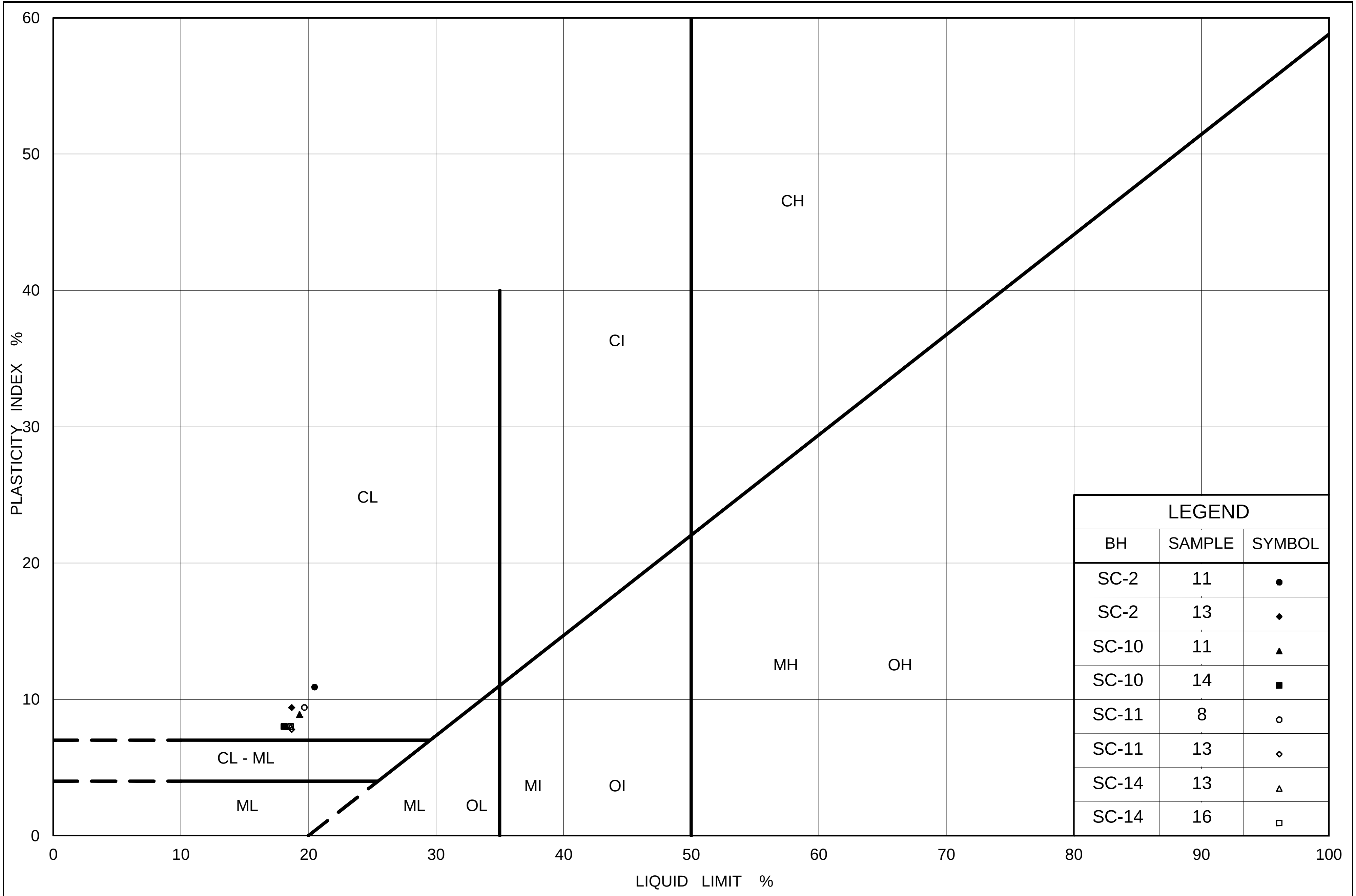
PLASTICITY CHART
Clayey Silt (Till)

Figure No. A10A

Project No. 09-1111-0018

Checked By: LCC

Oct 75, FF-S-21



BH	SAMPLE	SYMBOL
SC-2	11	●
SC-2	13	◆
SC-10	11	▲
SC-10	14	■
SC-11	8	○
SC-11	13	◇
SC-14	13	△
SC-14	16	□

Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt (Till)

Figure No. A10B

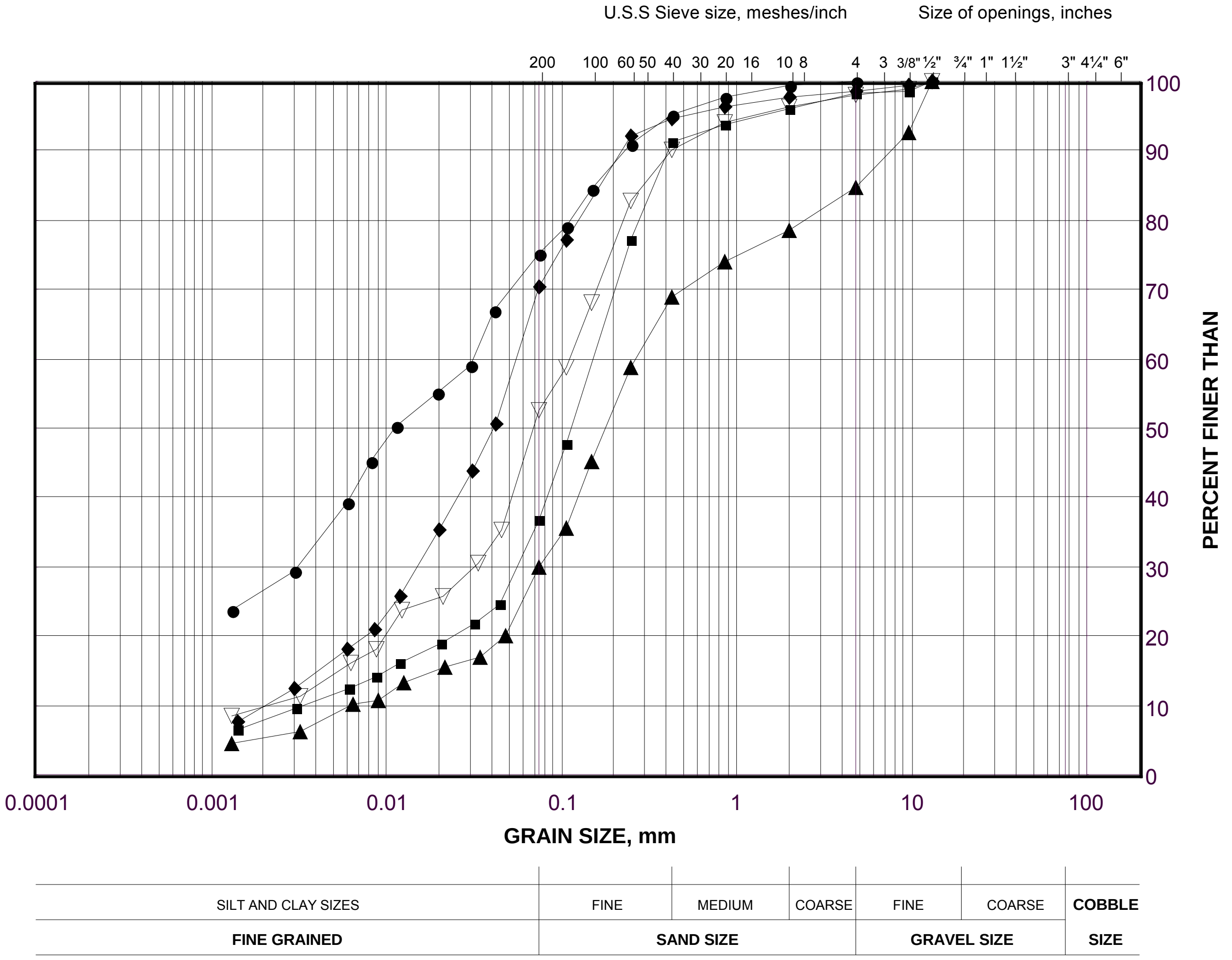
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Sandy Silt to Silty Sand Till

FIGURE A11



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	F8-6	11	216.8
■	SC-2	15	206.5
◆	F8-1	6	223.2
▲	F8-5	7	218.9
▽	F8-4	8	220.6

Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 10-Jan-13

APPENDIX B

Borehole Records and Laboratory Test Results - Highway 400 Embankment - SBL (Station 24+880 to 25+120) and NBL (Station 24+900 to 25+120)

Golder Associates

RECORD OF BOREHOLE No 12-3

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4877222.9 ;E 297142.4
BOREHOLE TYPE D-90 Truck Mount, 89 mm O.D. Tricone Wash Bore, N Casing
DATE May 28, 2012

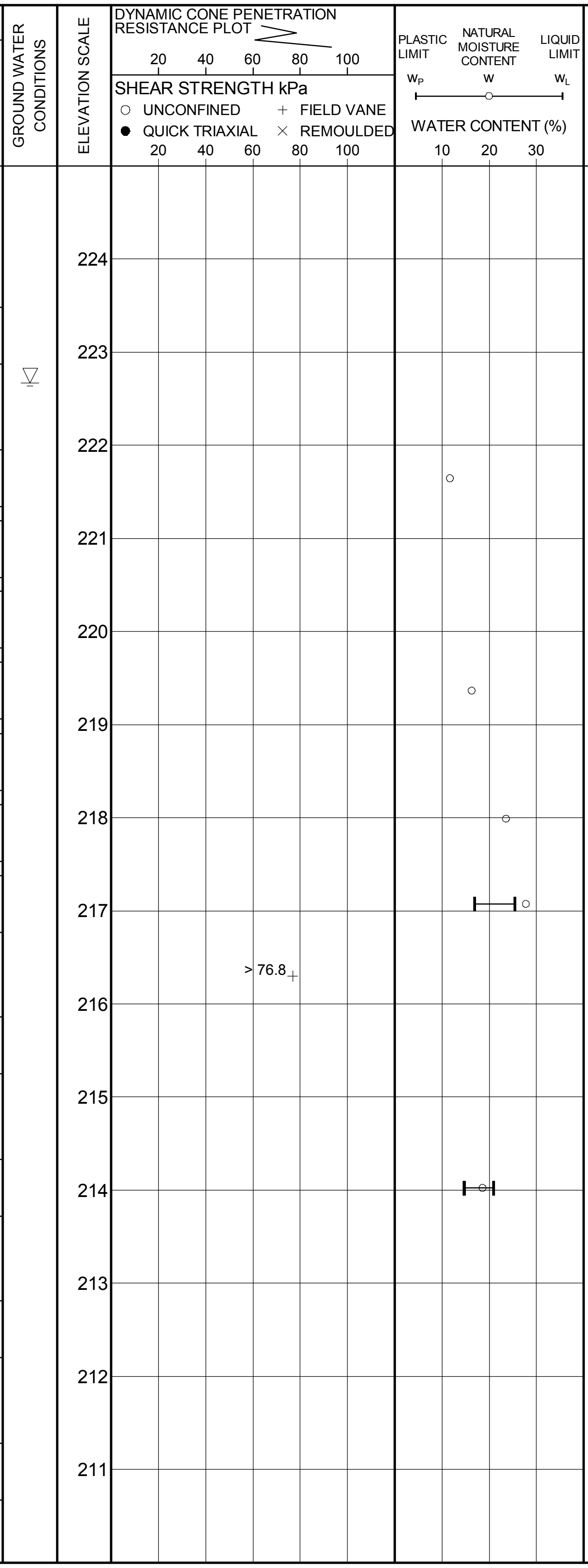
ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
225.0	GROUND SURFACE
0.0	ASPHALT
0.2	Sand and gravel, some silt, trace clay (FILL) Brown Moist
223.8 1.2	Clayey silt with sand, trace to some gravel, containing silty sand layers (FILL) Very stiff Grey Moist
222.4 2.6	Sand and silt, some clay, trace gravel, containing clayey silt seams (FILL) Very loose to dense Brown Wet
220.4 4.6	Clayey silt with sand, trace gravel, containing organics (FILL) Stiff to very stiff Brown and grey Moist
218.6	CLAYEY SILT, trace to some sand, trace gravel Stiff Grey Moist
218.2	SILTY SAND, trace clay, containing organics Loose Grey Wet
217.9 7.1	CLAYEY SILT, trace sand, containing organics to a depth of 7.5 m Firm to very stiff Grey Moist

SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	20				
2	SS	3	1	47	40	12
3	SS	33				
4	SS	27				
5	SS	9				
6A 6B	SS	13				
7A 7B	SS	6				
8	SS	3				
9	SS	12				
10	SS	7	0	4	77	19
11	SS	12				
12	SS	16				



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

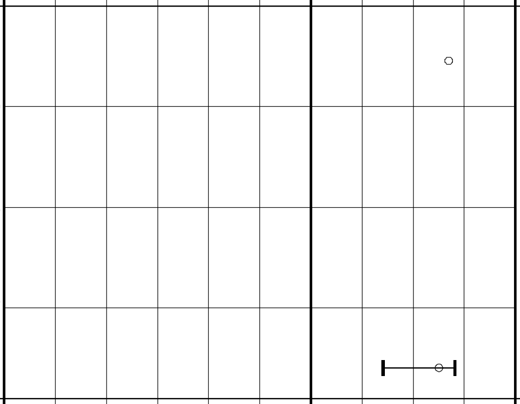
RECORD OF BOREHOLE No 12-3

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
LOCATION N 4877222.9 ;E 297142.4
ORIGINATED BY TWB
DIST Central HWY 400
BOREHOLE TYPE D-90 Truck Mount, 89 mm O.D. Tricone Wash Bore, N Casing
COMPILED BY CC
DATUM Geodetic
DATE May 28, 2012
CHECKED BY SMM

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAYEY SILT, trace sand, containing organics to a depth of 7.5 m Firm to very stiff Grey Moist	▨	13	SS	10						
							209				
			14	SS	8		208				
							207				
206.1			15	SS	5						
18.9	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 2.3 m below ground surface (Elev. 222.7 m) upon completion of drilling.										



+³, ×³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-4

SHEET 1 OF 2

METRIC

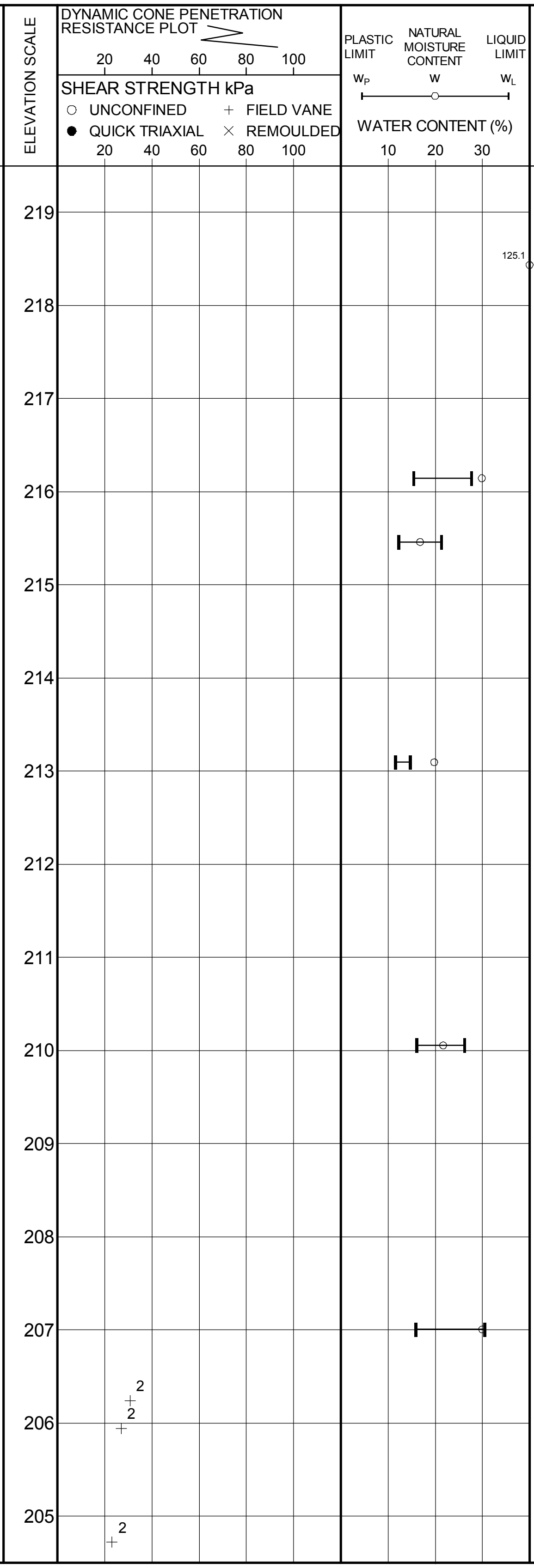
PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877275.6 ;E 297148.2
BOREHOLE TYPE D-50 Track Mount, 108 mm I.D. Hollow Stem Augers
DATE May 11, 2012
ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

SOIL PROFILE

ELEV DEPTH	DESCRIPTION	STRAT PLOT
219.5	GROUND SURFACE	
0.0	Sand and gravel, some silt, trace clay, containing organics below a depth of 0.5 m (FILL) Compact Brown Moist	▨
218.8 0.7	Sandy SILTY PEAT, trace clay, rootlets and wood fragments Very loose to loose Dark brown to black Moist	
217.1 2.4	CLAYEY SILT, trace sand, containing silty sand seams to a depth of 3.8 m, containing organics Very soft to soft Grey Moist	▨
214.9 4.6	SILT, some sand, some clay Loose Grey Wet	
212.3 7.2	CLAYEY SILT, trace sand Soft to stiff Grey Moist	▨

SAMPLES

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	SS	22						
2	SS	7		OC = 35%				
3	SS	1	∇					
4A 4B	SS	1						
5	SS	2			0	2	74	24
6	TO	PH		21.9 OC = 4.0%				
7	SS	9						
8	SS	4			0	13	70	17
9	SS	10						
10	SS	13						
11	SS	7						
12	SS	1						
13	SS	2						



Continued Next Page

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

Golder Associates

Foundation Design

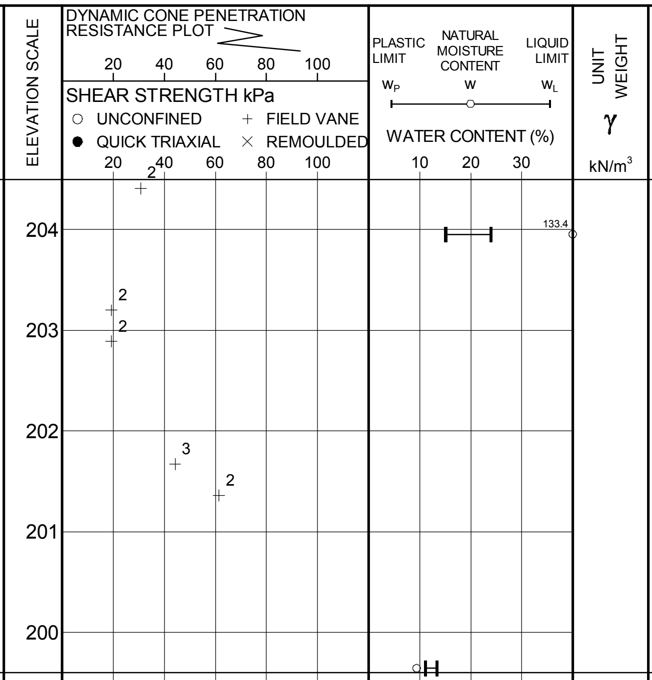
RECORD OF BOREHOLE No 12-4

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877275.6 ;E 297148.2
BOREHOLE TYPE D-50 Track Mount, 108 mm I.D. Hollow Stem Augers
DATE May 11, 2012
ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---							
	CLAYEY SILT, trace sand Soft to stiff Grey Moist	14	SS	1	0	1	71	28
		15	SS	3				
200.8		16	SS	52				
18.7	SAND and SILT, trace to some clay, trace gravel (TILL) Very dense Grey Moist	17	SS	50/0.13	3	47	40	10
199.6 19.9	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 2.0 m below ground surface (Elev. 217.5 m) upon completion of drilling.							



+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No 12-5

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018			
G.W.P. 2835-02-00	LOCATION N 4877314.1 ;E 297119.9		ORIGINATED BY TWB
DIST Central HWY 400	BOREHOLE TYPE D-90 Truck Mount, 89 mm O.D. Tricone Wash Bore, N Casing		COMPILED BY CC
DATUM Geodetic	DATE May 29, 2012		CHECKED BY SMM

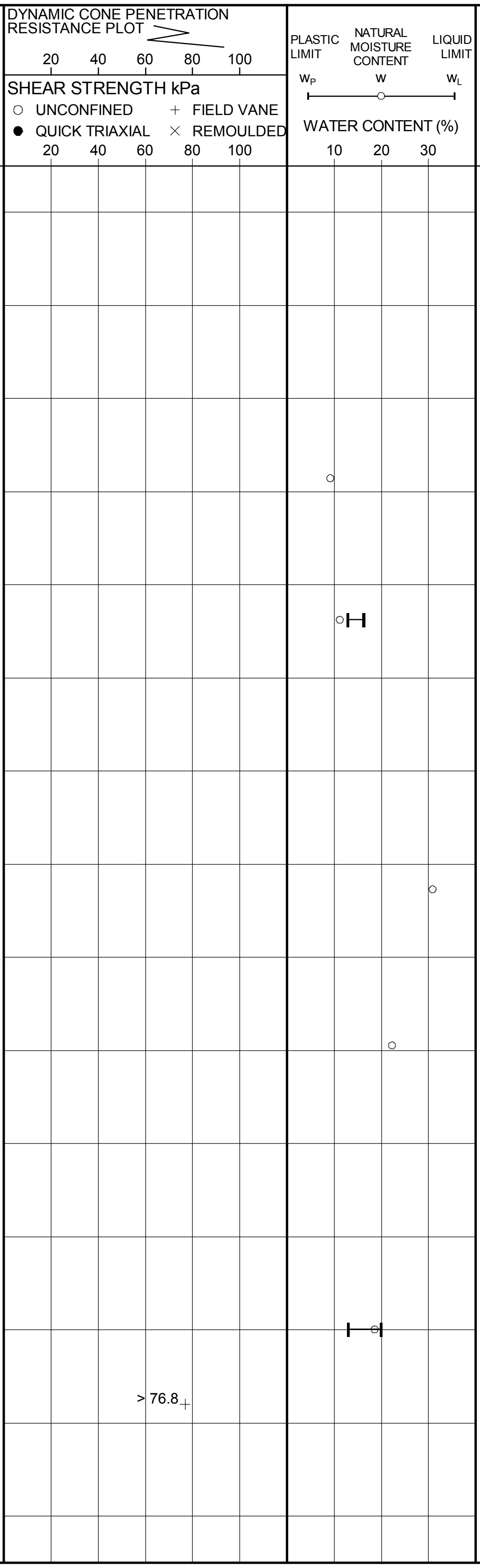
SOIL PROFILE

ELEV DEPTH	DESCRIPTION
223.5	GROUND SURFACE
0.0	ASPHALT
0.2	Sand and gravel, some silt, trace clay (FILL) Brown Moist
222.0 1.5	Clayey silt with sand, trace gravel, containing layers of silty sand (FILL) Firm Greyish brown Moist
220.5 3.0	Silty sand, trace clay, trace gravel (FILL) Loose Brown Wet
219.5 4.0	Sand and silt, trace to some clay, trace to some gravel (FILL) Compact Greyish brown Moist
216.3 7.2	CLAYEY SILT, trace sand Stiff Grey Moist
215.6 7.9	SAND and SILT, trace clay, containing organics to a depth of 8.7 m, becoming grey below a depth of 8.7 m Compact Greyish brown Wet
213.3 10.2	CLAYEY SILT, trace to some sand, silty sand seam from 10.8 m - 10.9 m depth Firm to stiff Grey Moist

SAMPLES

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	5		
2	SS	6	∇	
3	SS	5		
4A 4B	SS	27		
5	SS	23		11 37 42 10
6	SS	16		
7A 7B	SS	12		
8	SS	20		0 42 52 6
9	SS	11		
10	SS	4		0 11 64 25
11	SS	10		

ELEVATION SCALE: 223, 222, 221, 220, 219, 218, 217, 216, 215, 214, 213, 212, 211, 210, 209



UNIT WEIGHT γ kN/m³

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 12-5

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4877314.1 ;E 297119.9
BOREHOLE TYPE D-90 Truck Mount, 89 mm O.D. Tricone Wash Bore, N Casing
DATE May 29, 2012

ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
	CLAYEY SILT, trace to some sand, silty sand seam from 10.8 m - 10.9 m depth Firm to stiff Grey Moist		12	SS	7		208
							207
			13	SS	4		
							206
			14	SS	2		205
							204
			15	SS	15		203
201.6			16	SS	10		202
21.9	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 2.9 m below ground surface (Elev. 220.2 m) upon completion of drilling.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

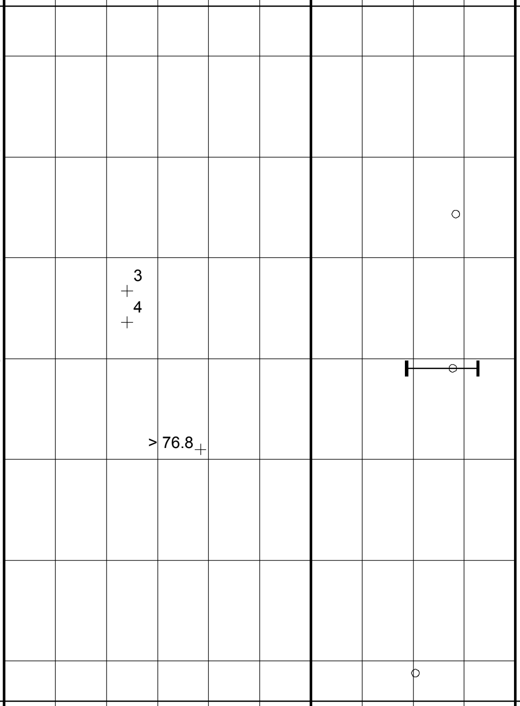
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL



+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-6

SHEET 1 OF 2

METRIC

PROJECT	09-1111-0018		
G.W.P.	2835-02-00	LOCATION	N 4877363.4 ;E 297126.5
DIST	Central HWY 400	BOREHOLE TYPE	D-50 Track Mount, 108 mm I.D. Hollow Stem Augers
DATUM	Geodetic	DATE	May 14, 2012
ORIGINATED BY	TWB	COMPILED BY	CC
CHECKED BY	SMM		

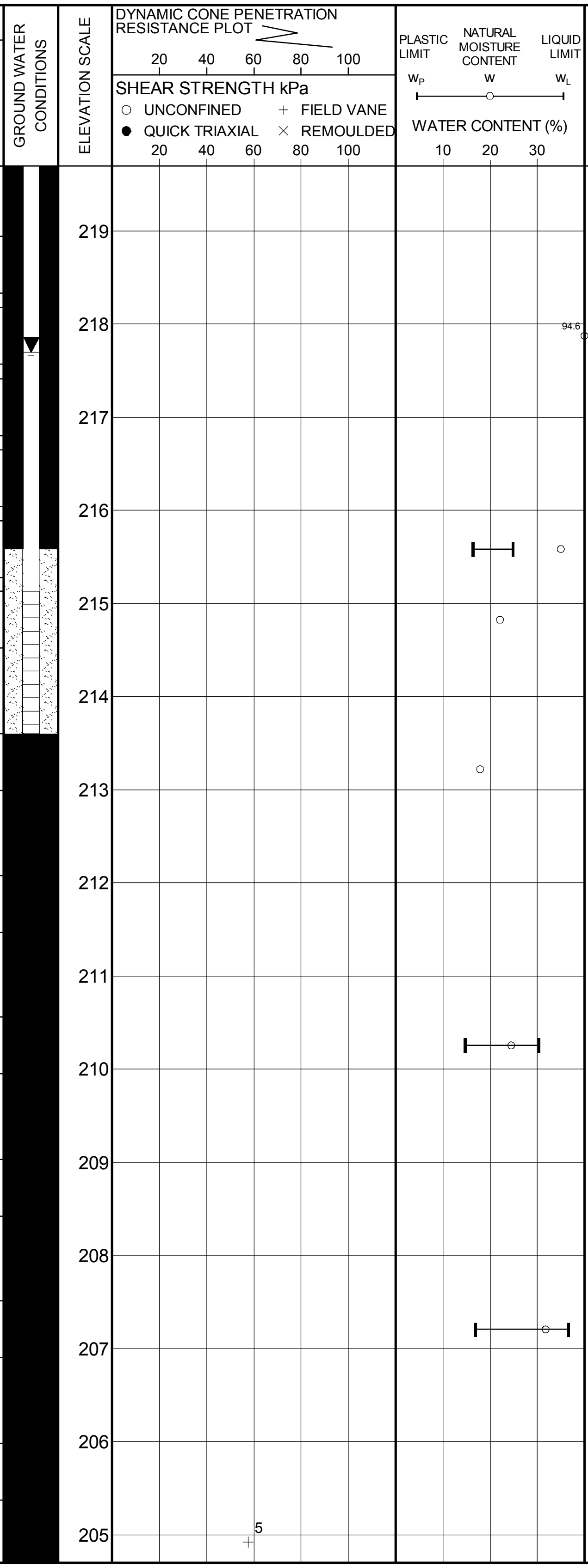
SOIL PROFILE

ELEV DEPTH	DESCRIPTION
219.7	GROUND SURFACE
~~0.0~~	ASPHALT
0.1	Sand and gravel, trace clay, trace silt (FILL) Brown Moist
219.0 0.7	Sandy SILTY PEAT, trace clay, rootlets and wood fragments Loose Dark brown
216.8 2.9	CLAYEY SILT some sand, trace gravel, containing organics, rootlets and wood fragments Very soft to soft Grey Moist
215.2 4.5	SAND and SILT, trace to some clay, trace gravel Compact Grey Wet
213.5 6.2	CLAYEY SILT, trace sand, containing organics Stiff Grey Moist
212.5 7.2	SAND and SILT, trace clay, containing wood fragments Compact Grey Wet
211.0 8.7	CLAYEY SILT to SILTY CLAY, trace sand Soft to stiff Grey Moist

Continued Next Page

SAMPLES

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	AS	-					
2	SS	4					
3	SS	4	OC = 24.7%				
4	SS	7					
5	SS	1					
6	SS	1	OC = 2.2%	3	20	59	18
7	SS	13		1	47	41	11
8A 8B	SS	13	OC = 1.4%				
9	SS	12					
10	SS	8					
11	SS	11					
12	SS	6		0	2	41	57
13	SS	1					



+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-6

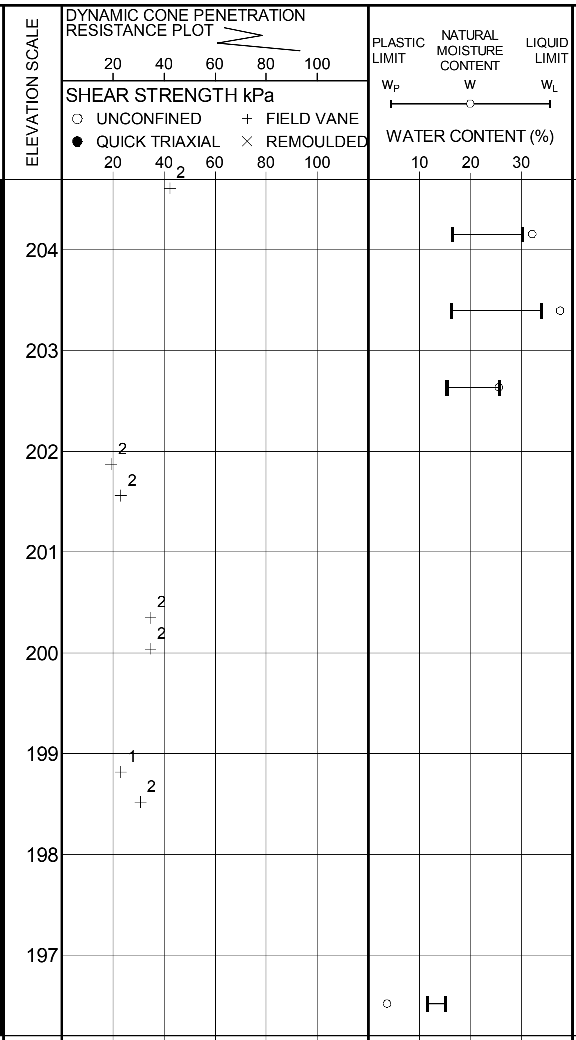
SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877363.4 ;E 297126.5
BOREHOLE TYPE D-50 Track Mount, 108 mm I.D. Hollow Stem Augers
DATE May 14, 2012
ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	CLAYEY SILT to SILTY CLAY, trace sand Soft to stiff Grey Moist	14	SS	WH					
		15	TO	PH	18.3				
		16	SS	WH					
		17	SS	1					
		18	SS	WH					
198.4 21.4	SILTY SAND, trace clay Dense Grey Wet	19A 19B	SS	37					
	SAND and SILT, trace to some clay, trace gravel, containing cobbles and boulders (TILL) Dense to very dense Grey Moist	20	SS	126		4	38	46	12
196.2 23.5	END OF BOREHOLE								



NOTES:

1. Water level in open borehole at a depth of 2.0 m below ground surface (Elev. 218.0 m) upon completion of drilling.

2. Water level in piezometer at a depth of 2.0 m below ground surface (Elev. 218.0 m) on May 15, 2012.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-7

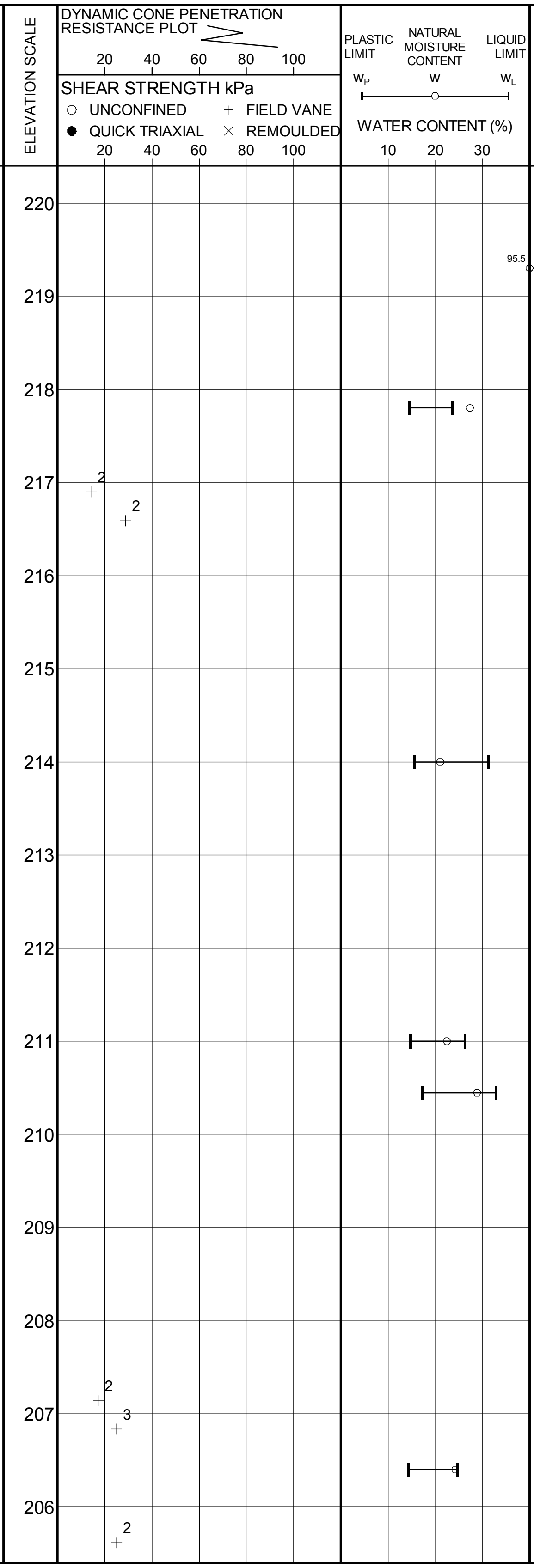
SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877186.9 ;E 297096.2
BOREHOLE TYPE D-50 Track Mount, 108 mm I.D. Hollow Stem Augers
DATE May 9, 2012
ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

ELEV DEPTH	SOIL PROFILE DESCRIPTION
220.4	GROUND SURFACE
0.0	TOPSOIL
219.9	
0.7	Clayey silt, trace to some sand, containing organics (FILL) Soft Brown Moist
	Sandy SILTY PEAT, trace clay, containing rootlets and wood fragments Very loose Dark brown to black Moist
218.2 2.2	CLAYEY SILT, trace sand Very soft to firm Grey Moist
216.6 3.8	SILTY SAND, trace clay Loose Grey Wet
215.9 4.5	CLAYEY SILT, trace sand, containing silty sand seams to a depth of 7.2 m Soft to stiff Grey Moist

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1A 1B	SS	3			
2	SS	3		OC = 22.9	
3	SS	1	▽		
4	SS	1			0 1 78 21
5	SS	7			
6	SS	7			
7	SS	12			
8	SS	11			
9	SS	4			
10	TO	PH		19.4	
11	SS	4			
12	SS	1			
13	SS	1			0 4 61 35



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+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No 12-7

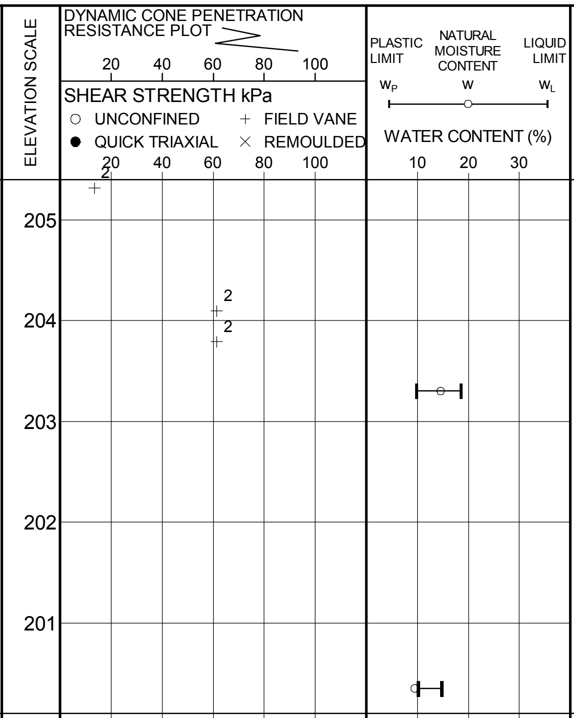
SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877186.9 ;E 297096.2
BOREHOLE TYPE D-50 Track Mount, 108 mm I.D. Hollow Stem Augers
DATE May 9, 2012
ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

--- CONTINUED FROM PREVIOUS PAGE ---

SOIL PROFILE			SAMPLES					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAYEY SILT, trace sand, containing silty sand seams to a depth of 7.2 m Soft to stiff Grey Moist		14	SS	1			
			15	SS	7			
202.7 17.7	SAND and SILT, some clay, trace gravel (TILL) Very dense Grey Moist		16	SS	93			
			17	SS	134			3 38 47 12
200.1 20.3	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 1.8 m below ground surface upon (Elev. 218.6 m) upon completion of drilling.							



+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

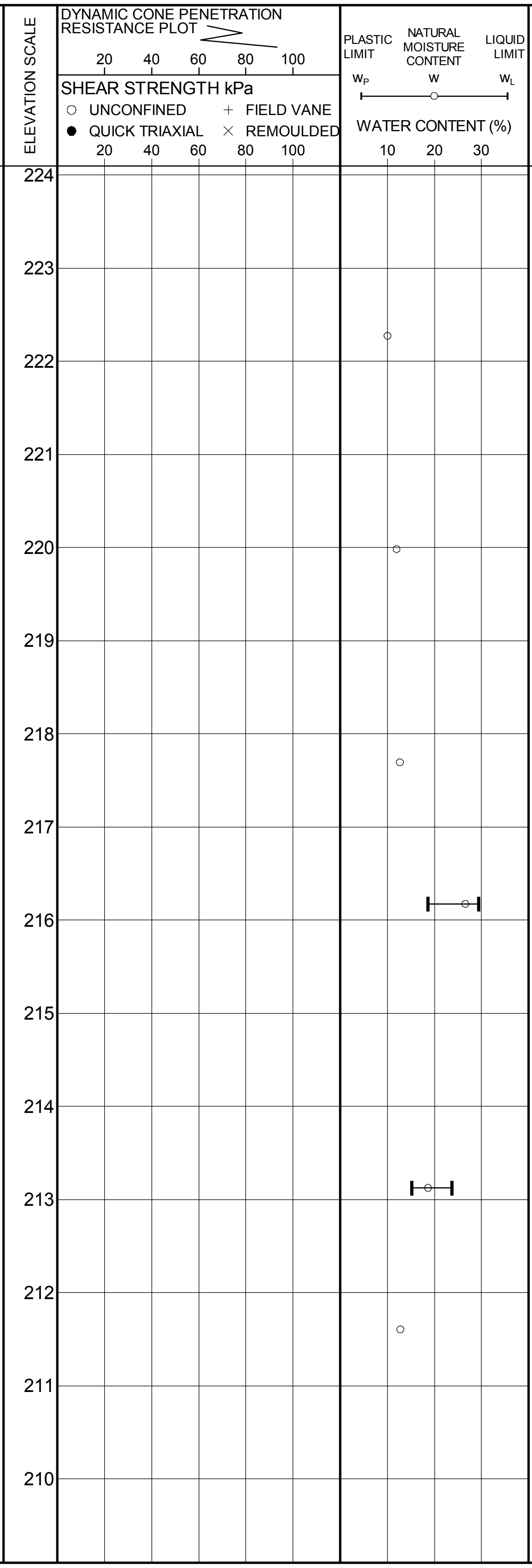
RECORD OF BOREHOLE No 12-8

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877236.1 ;E 297100.5
BOREHOLE TYPE D-90 Truck Mount, 89 mm O.D. Tricone Wash Bore, N Casing
DATE May 30, 2012
ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
224.1	GROUND SURFACE				
0.0	ASPHALT				
0.2	Sand and gravel, some silt, trace clay (FILL) Brown Moist				
222.6 1.5	Clayey silt with sand, trace gravel (FILL) Firm to stiff Brown Moist	1	SS	8	
		2	SS	15	
220.4 3.7	Sand and silt, trace clay, trace gravel (FILL) Dense Greyish brown Moist	3	SS	40	▽
219.6 4.5	Clayey silt with sand, trace gravel (FILL) Stiff to hard Brown Moist	4	SS	33	
		5	SS	17	
		6	SS	9	
		7A 7B	SS	9	
216.7 7.5	Silty SAND, trace clay Loose Grey Wet	8	SS	4	
	CLAYEY SILT, trace sand Firm Grey Moist				
215.4 8.7	Silty SAND, trace clay Compact Grey Wet	9	SS	19	
213.9 10.2	CLAYEY SILT, trace sand, trace to some gravel Firm to very stiff Grey Moist	10	SS	11	
		11	SS	17	
	some gravel between depths of 13.3 m - 14.8 m	12	SS	17	



UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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+3, ×3: Numbers refer to Sensitivity
○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-8

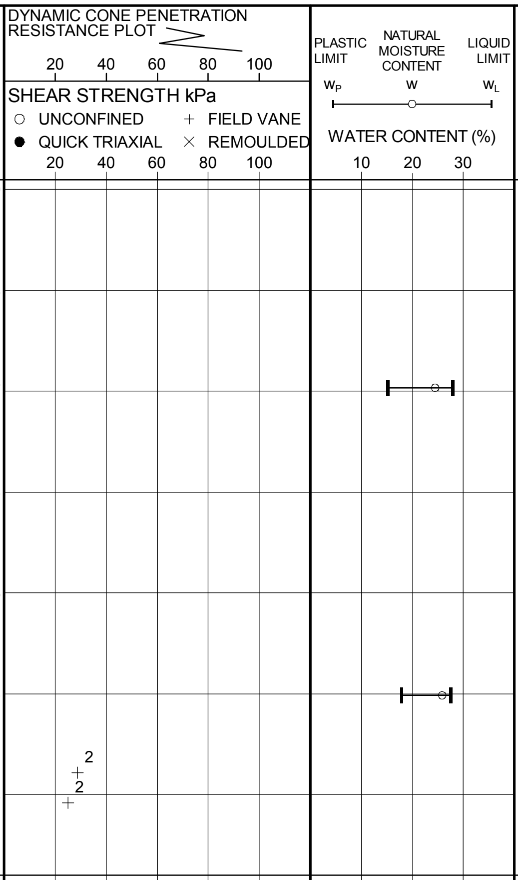
SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877236.1 ;E 297100.5
BOREHOLE TYPE D-90 Truck Mount, 89 mm O.D. Tricone Wash Bore, N Casing
DATE May 30, 2012
ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	CLAYEY SILT, trace sand, trace to some gravel Firm to very stiff Grey Moist	▨					209					
			13	SS	17							
							208					
			14	SS	8		207					
							206					
			15	SS	10							
							205					
			16	SS	2		204					
							203					
202.2			17	SS	7							
21.9	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 4.4 m below ground surface (Elev. 219.7 m) upon completion of drilling.											



+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Foundation Design

RECORD OF BOREHOLE No 12-9

SHEET 1 OF 2

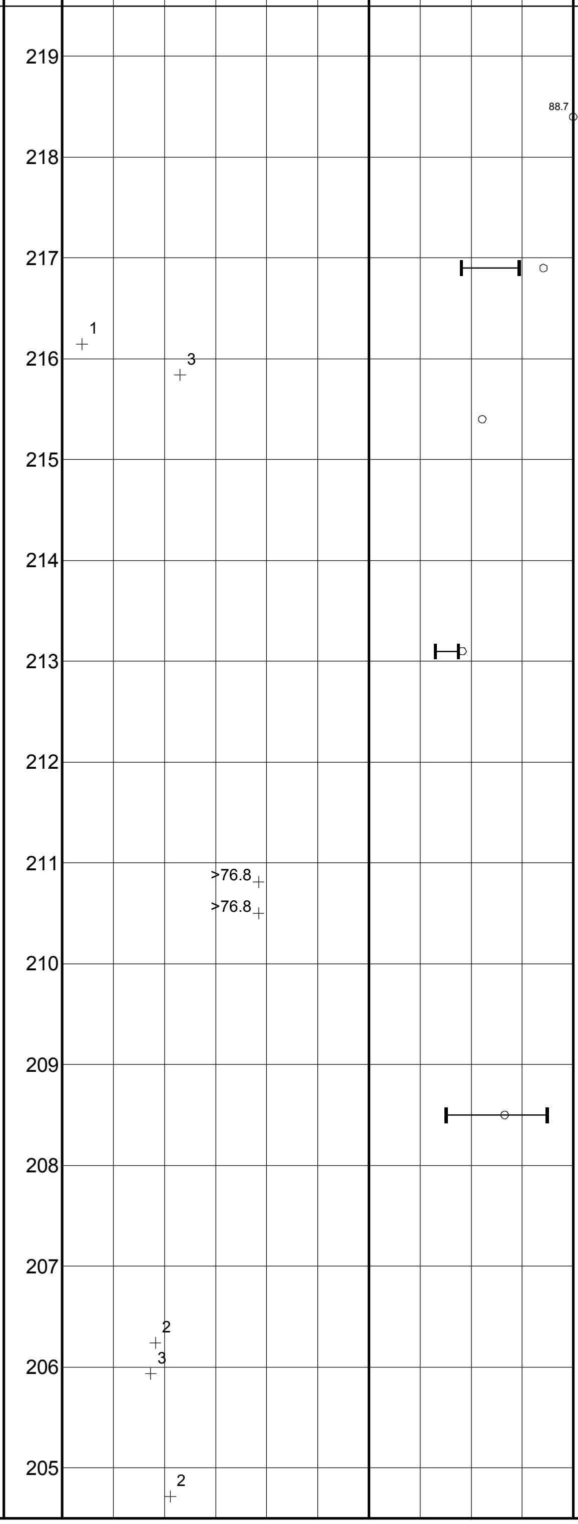
METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
LOCATION N 4877276.8 ;E 297071.9
ORIGINATED BY TWB
DIST Central HWY 400
BOREHOLE TYPE D-50 Track Mount, 108 mm I.D. Hollow Stem Augers
COMPILED BY CC
DATUM Geodetic
DATE May 10, 2012
CHECKED BY SMM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
219.5	GROUND SURFACE				
0.0	Clayey silt, trace to some sand, trace gravel, containing organics and rootlets (FILL) Very soft to soft Light brown Moist	1	SS	2	
218.9 0.6	SILTY PEAT, some sand, trace clay, containing rootlets and wood fragments Very loose to loose Dark brown to black Moist clayey silt seam from depth of 0.9 - 1.0 m depth	2	SS	6	OC = 18.3%
		3	SS	1	
217.3 2.2	CLAYEY SILT, trace sand Very soft to firm Grey Moist	4	SS	1	
215.7 3.8	SAND and SILT, trace to some clay Loose to compact Grey Wet	5	SS	13	0 34 59 7
		6A 6B	SS	8	
214.5 5.0	CLAYEY SILT, trace to some sand and gravel, Firm to stiff Grey Moist	7	SS	7	
	silty sand layer between depth of 7.8 - 7.9 m	8	SS	3	
		9	SS	11	
		10	SS	6	2 8 38 52
		11	SS	2	
		12	SS	7	

GROUND WATER CONDITIONS: ∇ (at approx. elev. 218.6)

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³



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+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-0018 (URS, YORK REGION)\LOG\0911110018.GPJ GAL-GTA.GDT 01/13/15 SIB

RECORD OF BOREHOLE No 12-9

SHEET 2 OF 2

METRIC

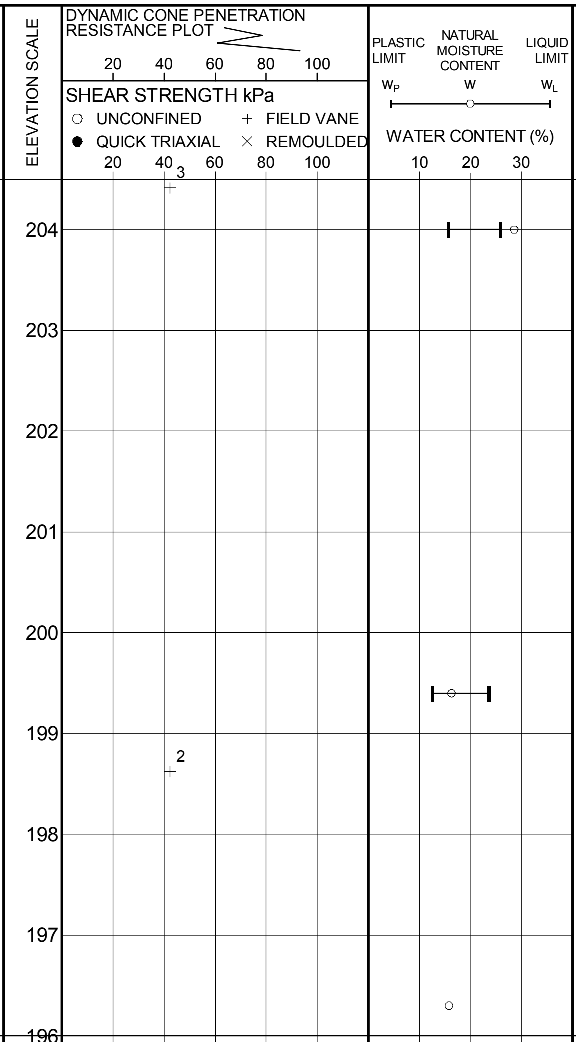
PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877276.8 ;E 297071.9
BOREHOLE TYPE D-50 Track Mount, 108 mm I.D. Hollow Stem Augers
DATE May 10, 2012
ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
	CLAYEY SILT, trace to some sand and gravel, Firm to stiff Grey Moist	13	SS	6					
		14	SS	7					
		15	SS	8					
		16	SS	1		10	13	39	38
198.5 21.0	SAND and SILT, trace clay, trace gravel (TILL) Dense Grey Wet	17	SS	39					
		18	SS	46		2	50	43	5
196.0 23.5	END OF BOREHOLE								

NOTE:

1. Water level in open borehole at a depth of 1.0 m below ground surface (Elev. 218.5 m) upon completion of drilling.



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-10

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

LOCATION N 4877324.8 ;E 297075.2

ORIGINATED BY TWB

DIST Central HWY 400

BOREHOLE TYPE D-90 Truck Mount, 89 mm O.D. Tricone Wash Bore, N Casing

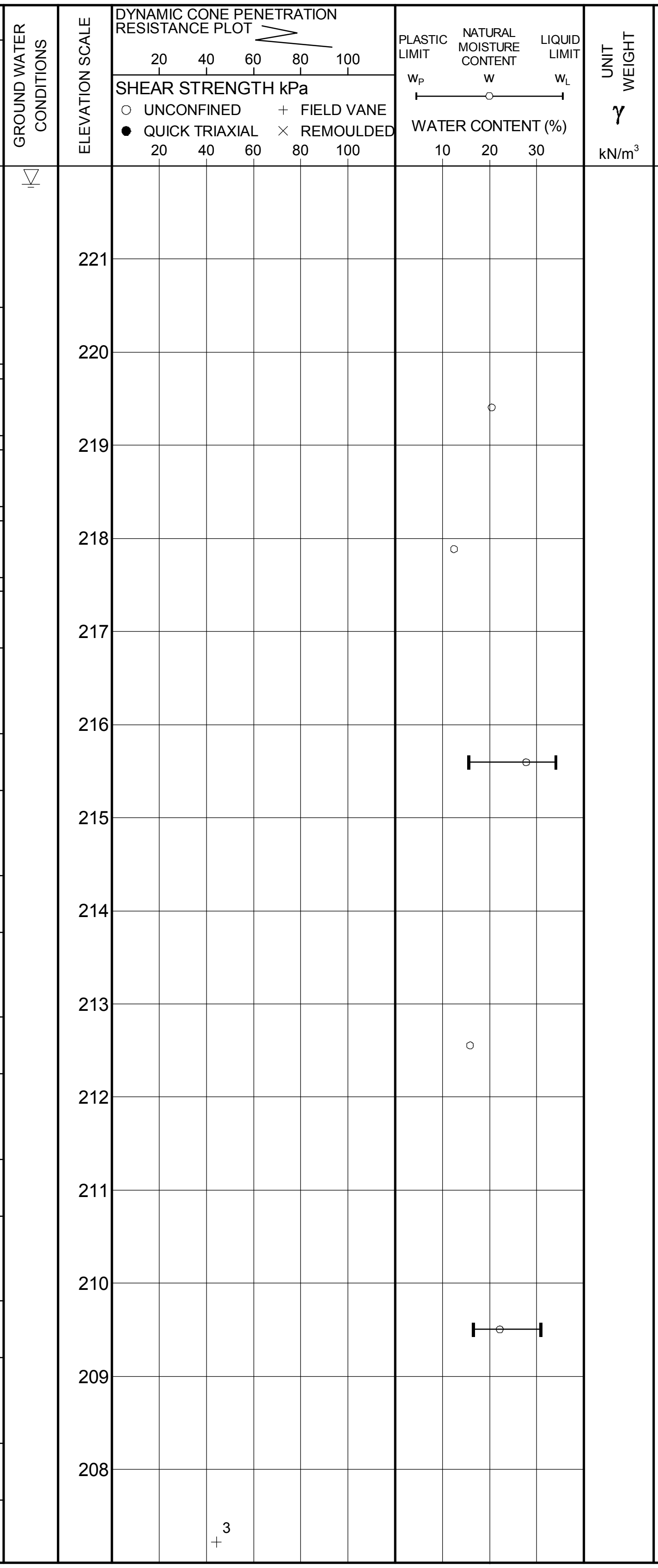
COMPILED BY CC

DATUM Geodetic

DATE May 30, 2012

CHECKED BY SMM

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
222.0	GROUND SURFACE							
0.0	ASPHALT							
0.2	Sand and gravel, some silt, trace clay (FILL) Brown Moist							
220.4 1.6	Clayey silt some to with sand, trace gravel (FILL) Soft to firm Brown to greyish brown Moist	1A 1B	SS	5				
		2	SS	2				
		3	SS	2				
		4	SS	3				
		5	SS	6				
216.8 5.2	CLAYEY SILT, trace sand Soft Grey Moist							
		6	SS	3	0	0	71	29
214.3 7.7	SILTY SAND, trace clay Compact Grey Wet	7	SS	23				
213.3 8.7	CLAYEY SILT to SILTY CLAY, trace sand Firm to very stiff Grey Moist							
		8	SS	7				
	sand seams between depths of 10.2 m and 11.7 m							
		9	SS	16				
		10	SS	11				
		11	SS	6				



Continued Next Page

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-10

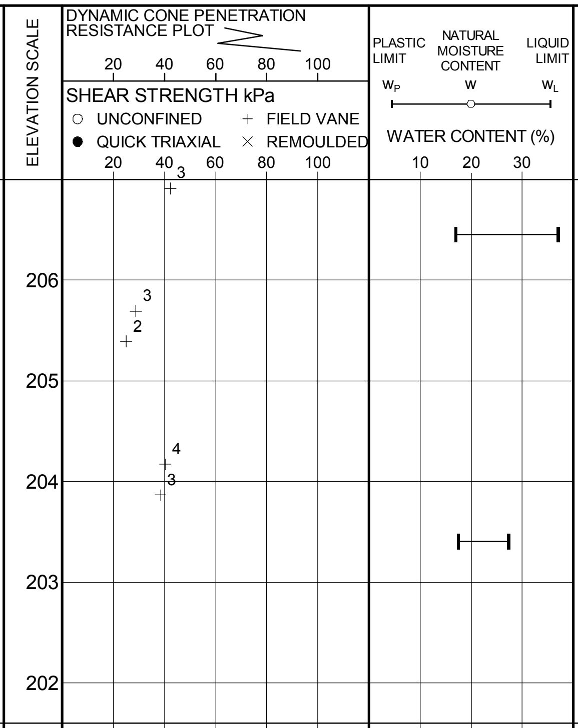
SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877324.8 ;E 297075.2
BOREHOLE TYPE D-90 Truck Mount, 89 mm O.D. Tricone Wash Bore, N Casing
DATE May 30, 2012
ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

--- CONTINUED FROM PREVIOUS PAGE ---

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			
	CLAYEY SILT to SILTY CLAY, trace sand Firm to very stiff Grey Moist		12	SS	4			
			13	SS	WH			
			14	SS	4			
201.6			15	SS	8			
20.4	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 0.1 m below ground surface (Elev. 221.9 m) upon completion of drilling.							



+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-5

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4877176.1 ;E 297165.0

BOREHOLE TYPE 108 mm Inside Diameter Hollow Stem Augers

DATE November 15, 2011

ORIGINATED BY TT

COMPILED BY NK

CHECKED BY LCC

SOIL PROFILE

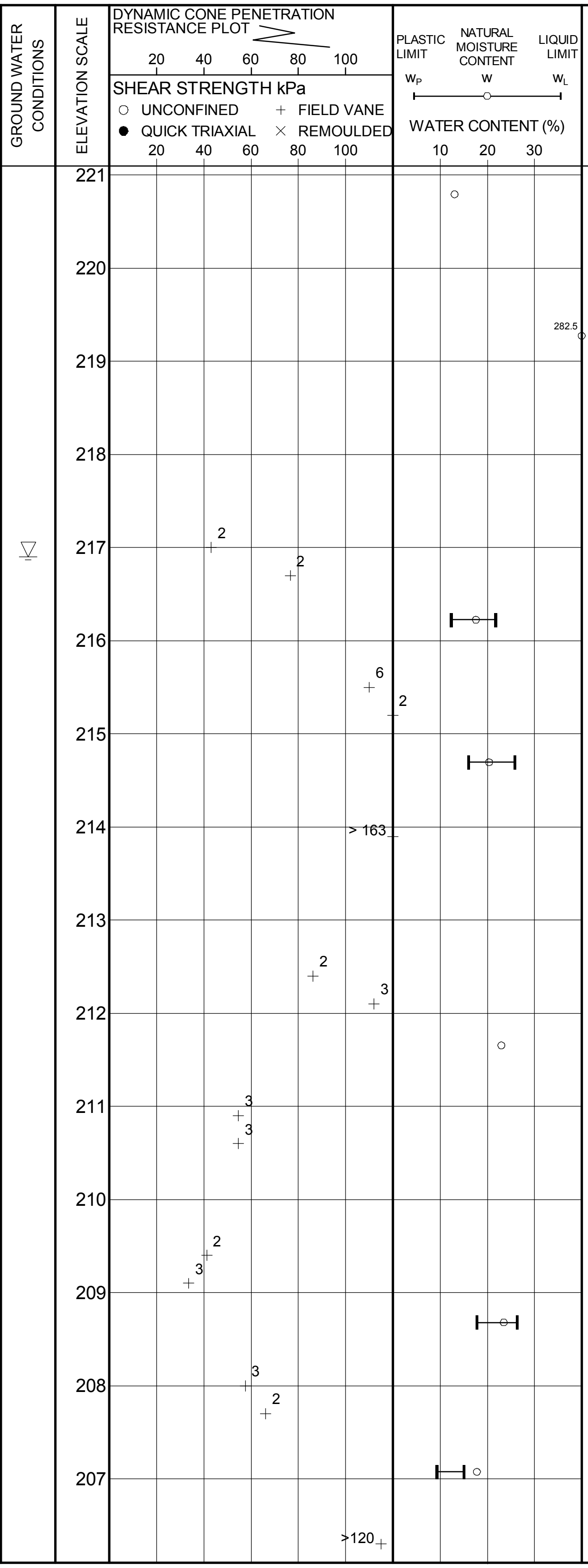
ELEV / DEPTH	DESCRIPTION
221.1	GROUND SURFACE
0.0	ASPHALT
	Sand and silt, trace gravel (FILL) Dense Brown Moist
220.4 / 0.7	Clayey silt with sand, trace gravel (FILL) Hard Grey Moist
	PEAT, some silt Soft Black Moist
218.9 / 2.2	CLAYEY SILT, some sand Very soft to soft Grey Moist
218.3	
217.9 / 3.2	Sandy SILT, trace clay Grey Wet
	CLAYEY SILT, trace to some sand, trace gravel, containing sand seams and interlayers at a depth of 13.7 m Firm to very stiff Grey Moist
206.3 / 14.8	

Continued Next Page

SAMPLES

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	SS	34					
2	SS	3					
3	SS	2					
4	SS	1					
5	SS	2					
6	SS	9		1	7	66	26
7	SS	15					
8	SS	13					
9	SS	7					
10	SS	1					
T1	TO	PH	20.1 Oed				
11	SS	13		4	29	39	28

GROUND WATER CONDITIONS: ∇ at elevation 217



REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-5

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

LOCATION N 4877176.1 ;E 297165.0

ORIGINATED BY TT

DIST Central HWY 400

BOREHOLE TYPE 108 mm Inside Diameter Hollow Stem Augers

COMPILED BY NK

DATUM Geodetic

DATE November 15, 2011

CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAYEY SILT, some sand, trace gravel (TILL) Hard Grey Moist						206				
205.3 15.9			12	SS	66						
	END OF BOREHOLE NOTES: 1. Blowing sands encountered at a depth of 15.2 m (Elev. 205.9 m) 2. Water level in open borehole at a depth of 4.2 m (Elev. 216.9 m) on completion of drilling.										

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$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-7

SHEET 1 OF 3

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4877117.8 ;E 297113.1

BOREHOLE TYPE 108 mm Inside Diameter Hollow Stem Augers

DATE November 7, 2011

ORIGINATED BY SB/TT

COMPILED BY NK

CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
220.7	GROUND SURFACE										
0.0	Clayey silt, trace sand, trace gravel, containing roots and organic matter (FILL) Very stiff Brown Moist		1	SS	25						
219.9 0.8	PEAT (Fibrous), trace clay Very soft to stiff Black and brown Moist		2	SS	9						
			3	SS	3						
218.4 2.3	CLAYEY SILT, trace sand and peat Soft Grey Moist		4	SS	3						
217.6 3.1	Silty SAND, trace clay Loose Grey Moist		5	SS	4						
216.9 3.8	CLAYEY SILT to SILT, trace to some clay, trace to some sand, trace gravel Firm to very stiff Grey Moist		6	SS	5			0	6	80	14
			7	TO	PH						
			8	SS	17						
			9	SS	21						
			10	SS	8						
			11	TO	PH		20.6 Oed				
			12	SS	WH			2	20	57	21
207.0 13.7	CLAYEY SILT, trace sand, trace gravel (TILL) Hard Grey Moist		13	SS	32						

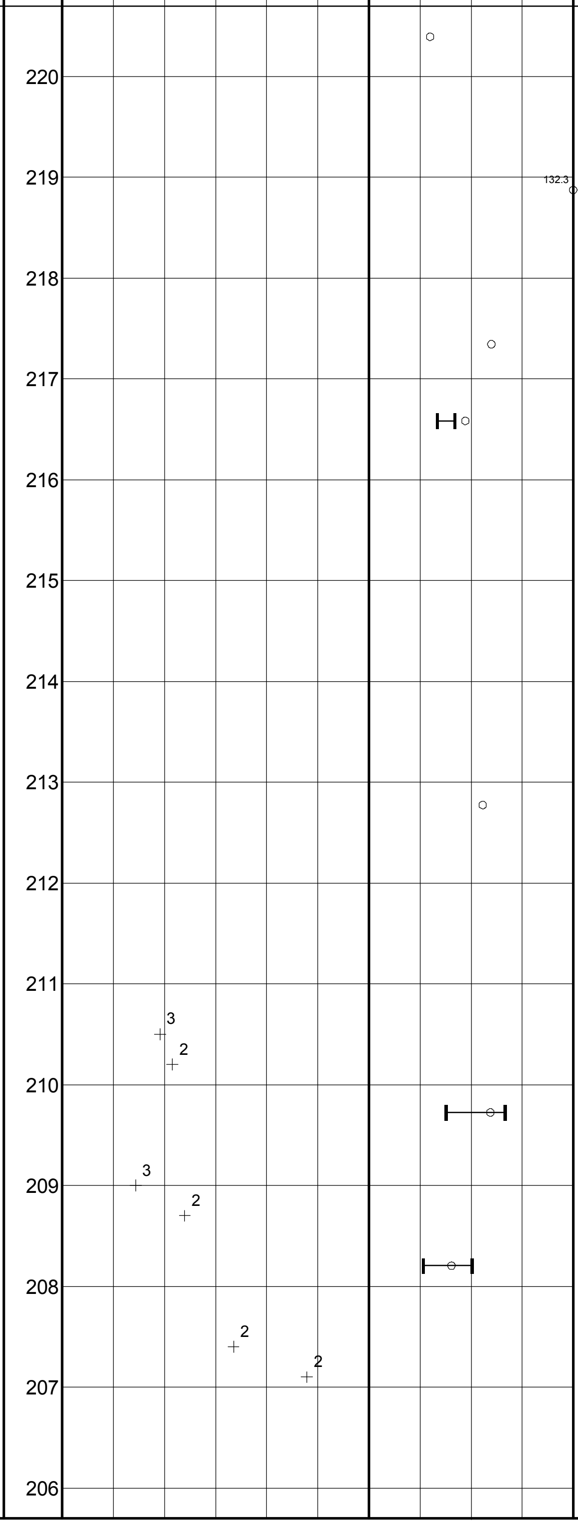
ELEVATION SCALE

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%) 10 20 30



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+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-7

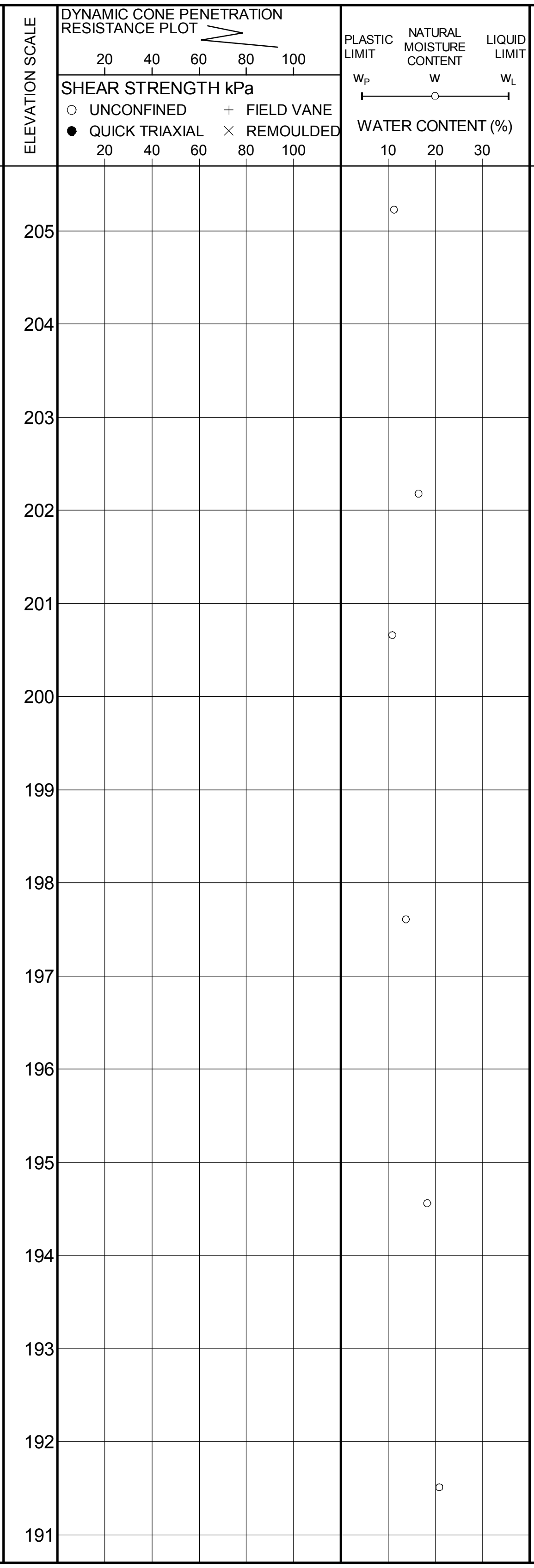
SHEET 2 OF 3

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877117.8 ;E 297113.1
BOREHOLE TYPE 108 mm Inside Diameter Hollow Stem Augers
DATE November 7, 2011
ORIGINATED BY SB/TT
COMPILED BY NK
CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
205.5										
15.2	SAND and SILT, trace to some gravel, trace clay Very dense Grey Moist to wet Blowing sand encountered at a depth of 15.8 m	14	SS	146			1	38	52	9
		15	SS	93						
		16	SS	63						
201.4 19.3	SAND and GRAVEL, trace silt and clay Very dense Grey Wet	17	SS	69			33	59	6	2
199.9 20.8	SAND and SILT to SAND, trace to some silt, trace gravel and clay Very dense Grey Wet	18	SS	106						
		19	SS	76						
		20	SS	64						
		21	SS	72			0	85	10	5
		22	SS	61						
		23	SS	71						



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+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-7

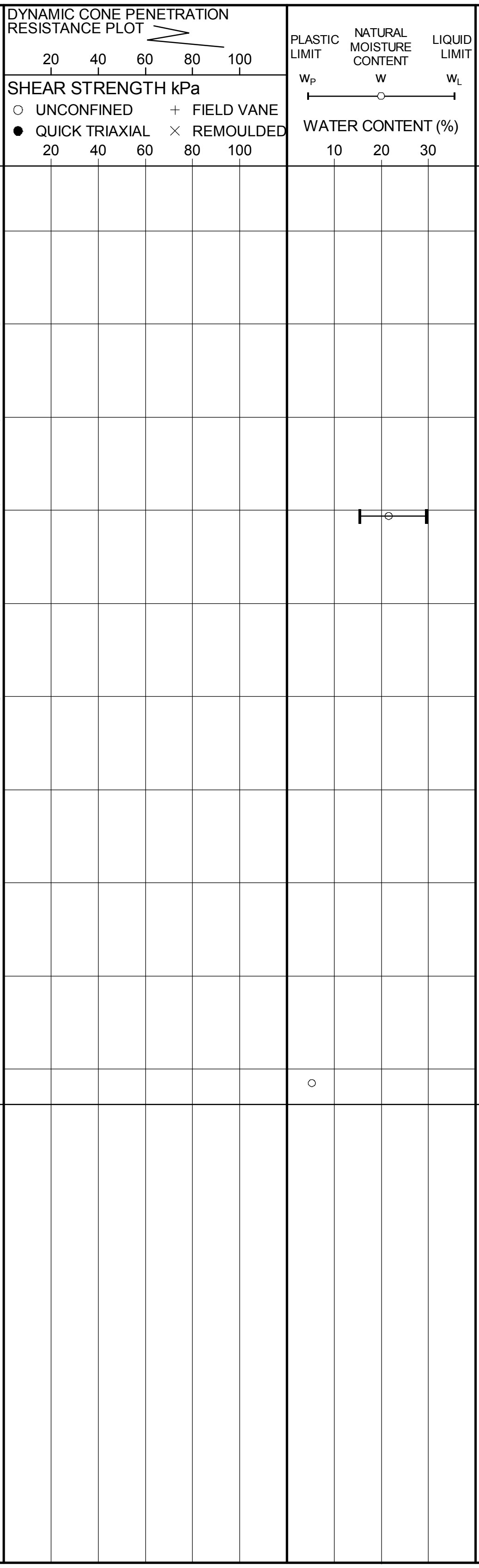
SHEET 3 OF 3

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877117.8 ;E 297113.1
BOREHOLE TYPE 108 mm Inside Diameter Hollow Stem Augers
DATE November 7, 2011
ORIGINATED BY SB/TT
COMPILED BY NK
CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	SAND and SILT to SAND, trace to some silt, trace gravel and clay Very dense Grey Wet	24	SS	61	190				
					189				
188.4 32.3	CLAYEY SILT, trace sand, trace gravel, containing silt seams Hard Grey Moist				188				
		25	SS	52	187	1	1	65	33
					186				
					185				
		26	SS	67	184				
					183				
182.3 38.4	SAND and GRAVEL, some silt, trace clay Very dense Grey Wet				182				
		27	SS	87	181	47	39	13	1
180.6 40.1	END OF BOREHOLE								



NOTES:

1. Blowing sands and artesian conditions encountered below a depth of 15.7 m (Elev. 205.0m).

2. Tricone and wash boring used below a depth of 15.2 m (Elev. 205.5 m) due to artesian conditions in the sand layer.

3. Artesian pressure up to 1.5 m above ground surface (Elev. 222.2 m) noted during removal of hollow stem augers.

4. Borehole caved at a depth of 36.6 m (Elev. 184.1 m) on completion of drilling.

5. Borehole abandoned using cement grout, with 3 m of bentonite placed above the grout immediately below ground surface.

$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-8

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018			
G.W.P. 2835-02-00	LOCATION N 4877130.1 ;E 297103.5		ORIGINATED BY SB
DIST Central HWY 400	BOREHOLE TYPE 108 mm Inside Diameter Hollow Stem Augers		COMPILED BY NK
DATUM Geodetic	DATE November 7, 2011		CHECKED BY LCC

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
220.5	GROUND SURFACE
0.0	TOPSOIL
0.2	CLAYEY SILT, trace sand, trace gravel, containing organic matter Stiff Brown and grey Moist
218.7 1.8	PEAT (Fibrous) Firm Black Moist
218.2 2.3	CLAYEY SILT, trace sand Very soft Grey Moist
217.0 3.7	Silty SAND Very loose Grey Moist
	CLAYEY SILT to SILT, some clay, trace to some sand Soft to very stiff Grey Moist
207.7 12.8	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 5.5 m (Elev. 215.0 m) on completion of drilling.

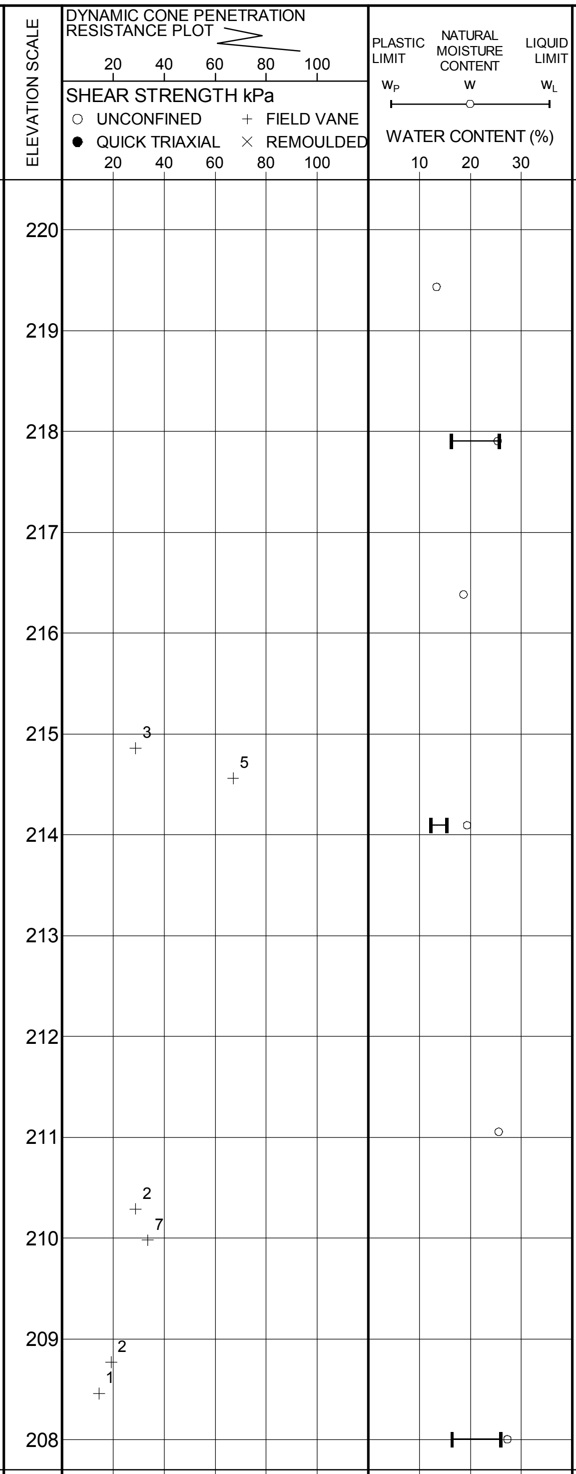
SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	13				
2	SS	11				
3	SS	5				
4	SS	2	0	1	85	14
5	SS	WH				
6	SS	7				
7	SS	6				
8	SS	24	0	15	71	14
9	SS	18				
10	SS	WH				
11	SS	WH				
12	SS	WH	0	2	68	30

GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL



+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-0018 (URS, YORK REGION)\LOG\0911110018.GPJ GAL-GTA.GDT 01/13/15 SIB

RECORD OF BOREHOLE No B0-9

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

LOCATION N 4877161.8 ;E 297169.1

ORIGINATED BY TZ

DIST Central HWY 400

BOREHOLE TYPE 108 mm Inside Diameter Hollow Stem Augers

COMPILED BY NK

DATUM Geodetic

DATE November 14-15, 2011

CHECKED BY LCC

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
221.0	GROUND SURFACE
0.0	TOPSOIL
0.1	CLAYEY SILT, trace gravel, trace sand, containing organics Firm Brown Moist
219.5 1.5	PEAT (Amorphous), containing rootlets and decomposed wood fragments, containing clayey silt seams Firm Black Moist
218.4 2.6	CLAYEY SILT, trace to some sand Firm to stiff Grey Moist
215.5 5.5	Silty SAND, some gravel, trace clay Compact Grey Wet
214.7 6.3	CLAYEY SILT, trace sand Stiff to very stiff Grey Wet
206.2 14.8	

Continued Next Page

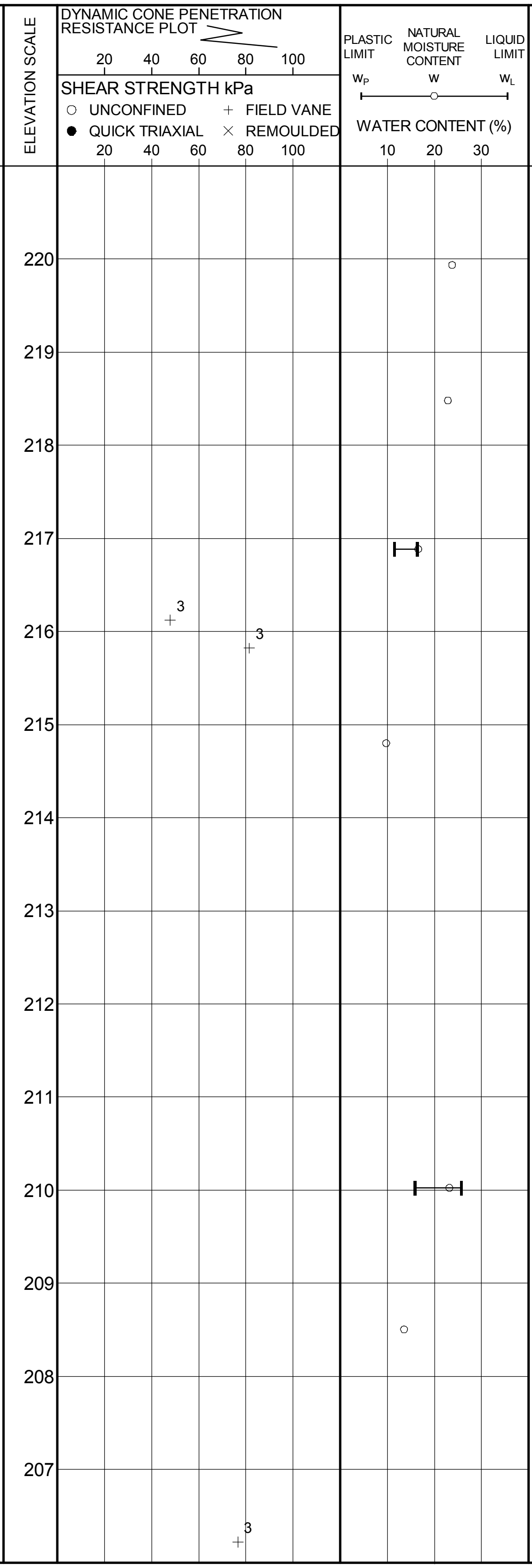
SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	5				
2	SS	4				
3	SS	7				
4	SS	9				
5	SS	2	0	18	72	10
6	SS	19				
7A 7B	SS	19	19	47	29	5
8	SS	17				
9	SS	13				
10	SS	12	0	2	71	27
11	SS	11				
12	SS	8				

GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)



+³, ×³: Numbers refer to Sensitivity

○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No B0-9

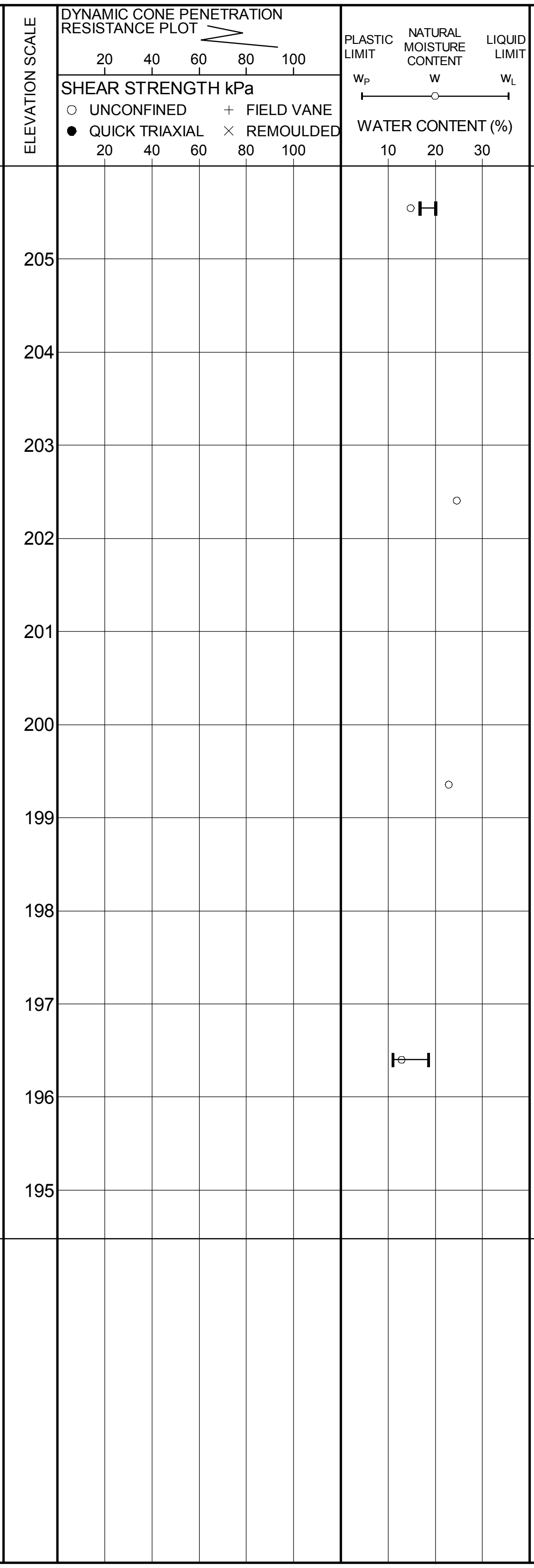
SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877161.8 ;E 297169.1
BOREHOLE TYPE 108 mm Inside Diameter Hollow Stem Augers
DATE November 14-15, 2011
ORIGINATED BY TZ
COMPILED BY NK
CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	SILT, some clay Very dense Grey Moist	13	SS	116/0.28	0	0	87	13
		14	SS	286				
203.2 17.8	SAND and SILT, trace to some clay Compact to very dense Grey Wet	15	SS	69	0	32	56	12
		16	SS	83				
		17	SS	21				
		18	SS	102				
197.1 23.9	CLAYEY SILT with sand, some gravel Hard Grey Wet	19A	SS	100	16	25	44	15
196.2 24.8	SAND, trace gravel, trace silt Very dense Grey Wet	19B						
195.5 25.5	SAND and GRAVEL Very dense Grey Wet	20	SS	101				
194.5 26.5	END OF BOREHOLE							



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTES:

1. Artesian conditions encountered below a depth of 25.9 m (Elev. 195.1 m).

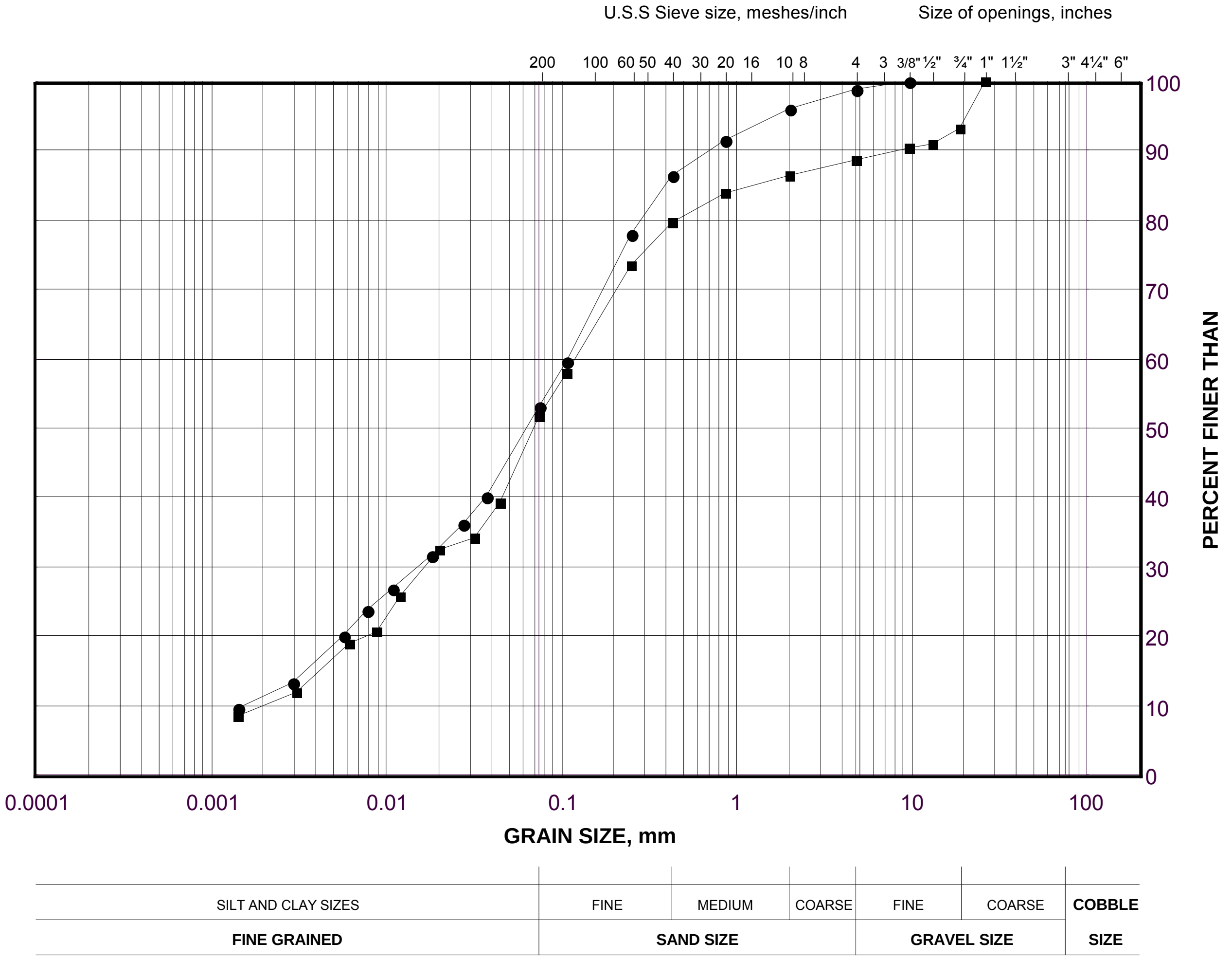
2. Water level measured inside casing at 1.6 m above ground surface (Elev. 222.6 m) on completion of drilling.

3. Borehole abandoned using cement grout with 3 m of bentonite placed above grout immediately below ground surface.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GRAIN SIZE DISTRIBUTION
Sand and Silt (Fill)

FIGURE B1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-3	2	221.7
■	12-5	5	218.6

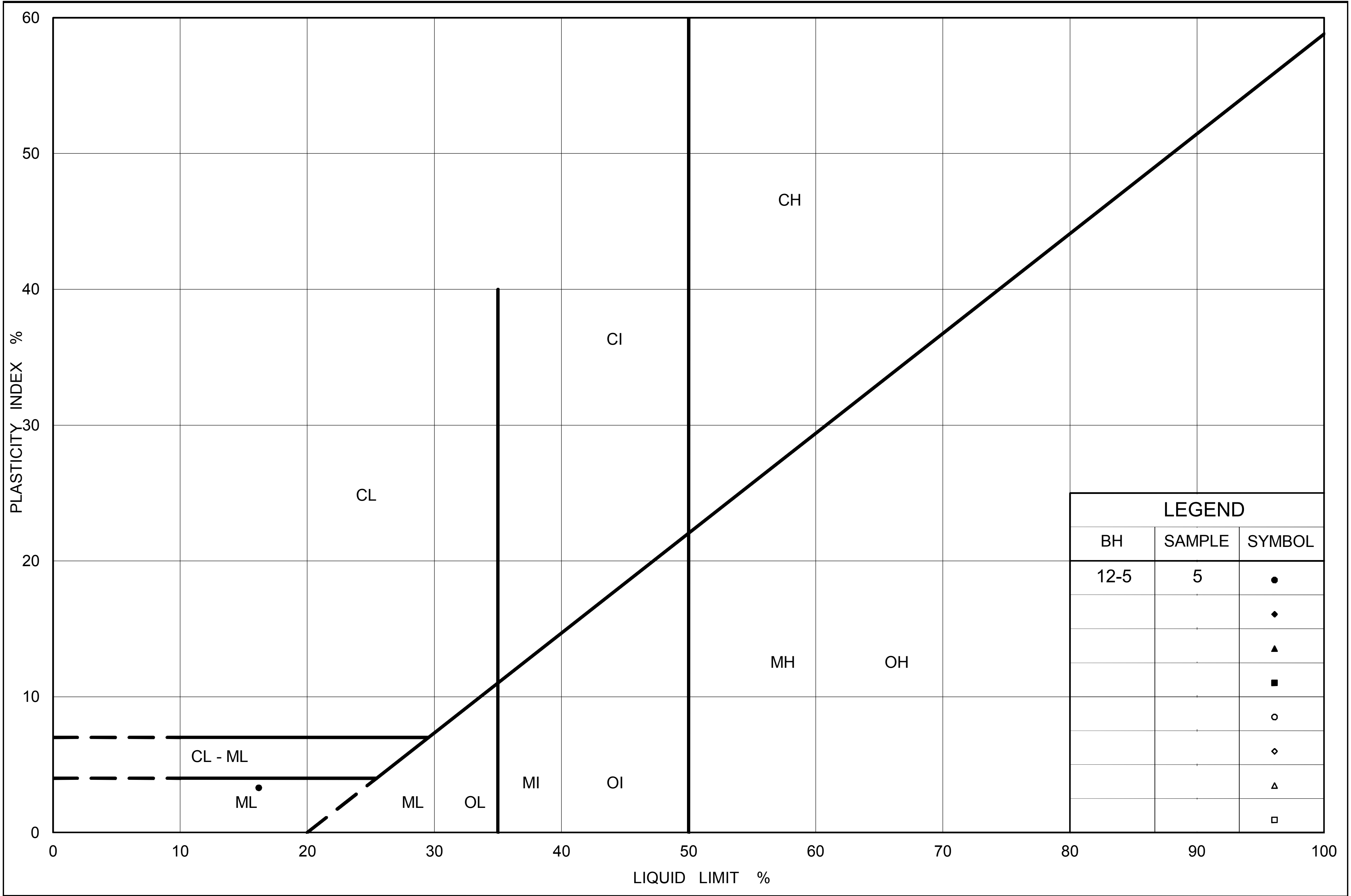
Project Number: 09-1111-0018

Checked By: ______________________

Golder Associates

Date: 25-Jan-13

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Sand and Silt (Fill)

Figure No. B2

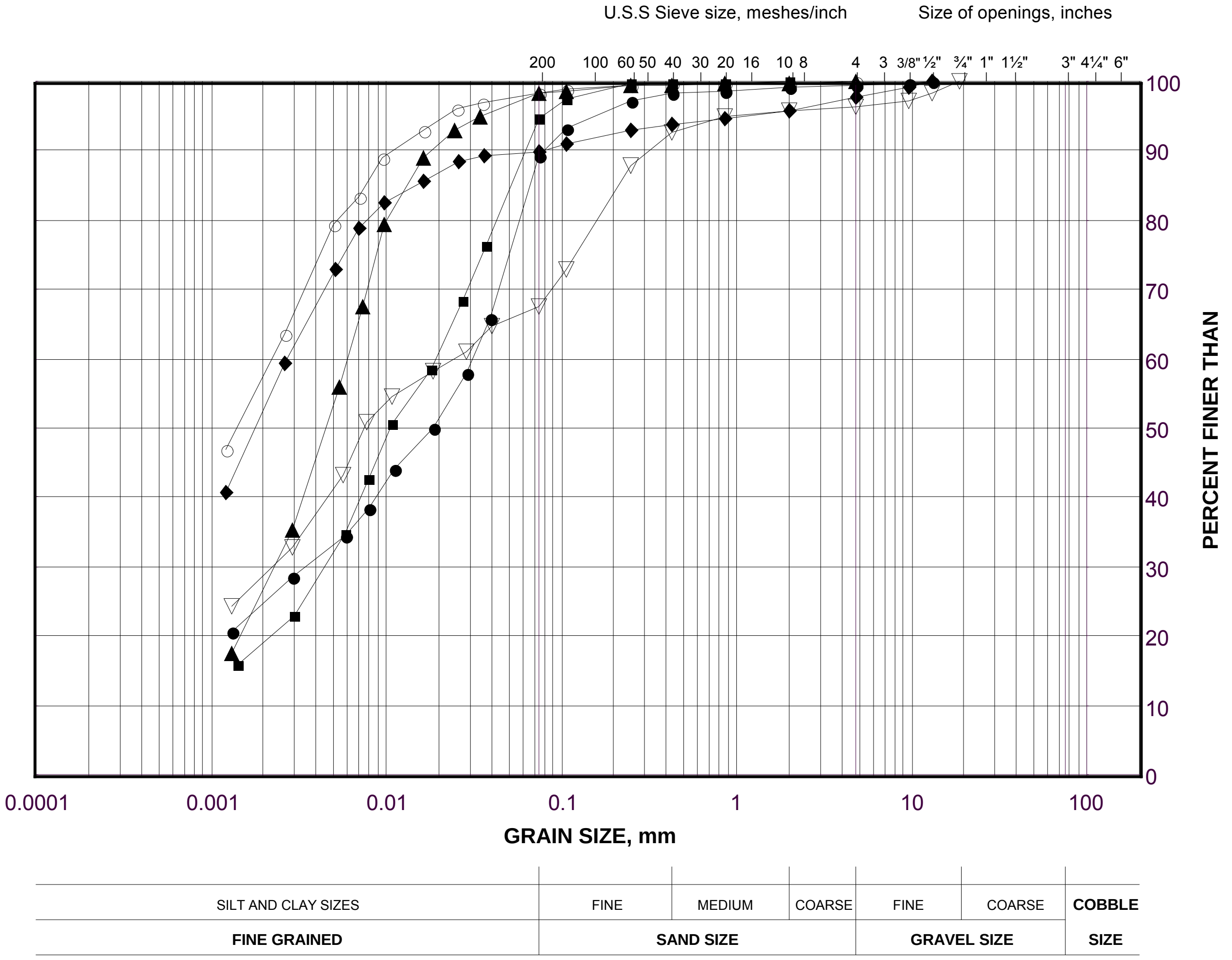
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay (Upper Deposit)

FIGURE B3A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-5	10	211.0
■	12-3	10	214.0
◆	12-9	10	208.5
▲	BO-9	10	210.0
▽	SC-5	11	207.1
○	12-6	12	207.2

Project Number: 09-1111-0018

Checked By: LCC

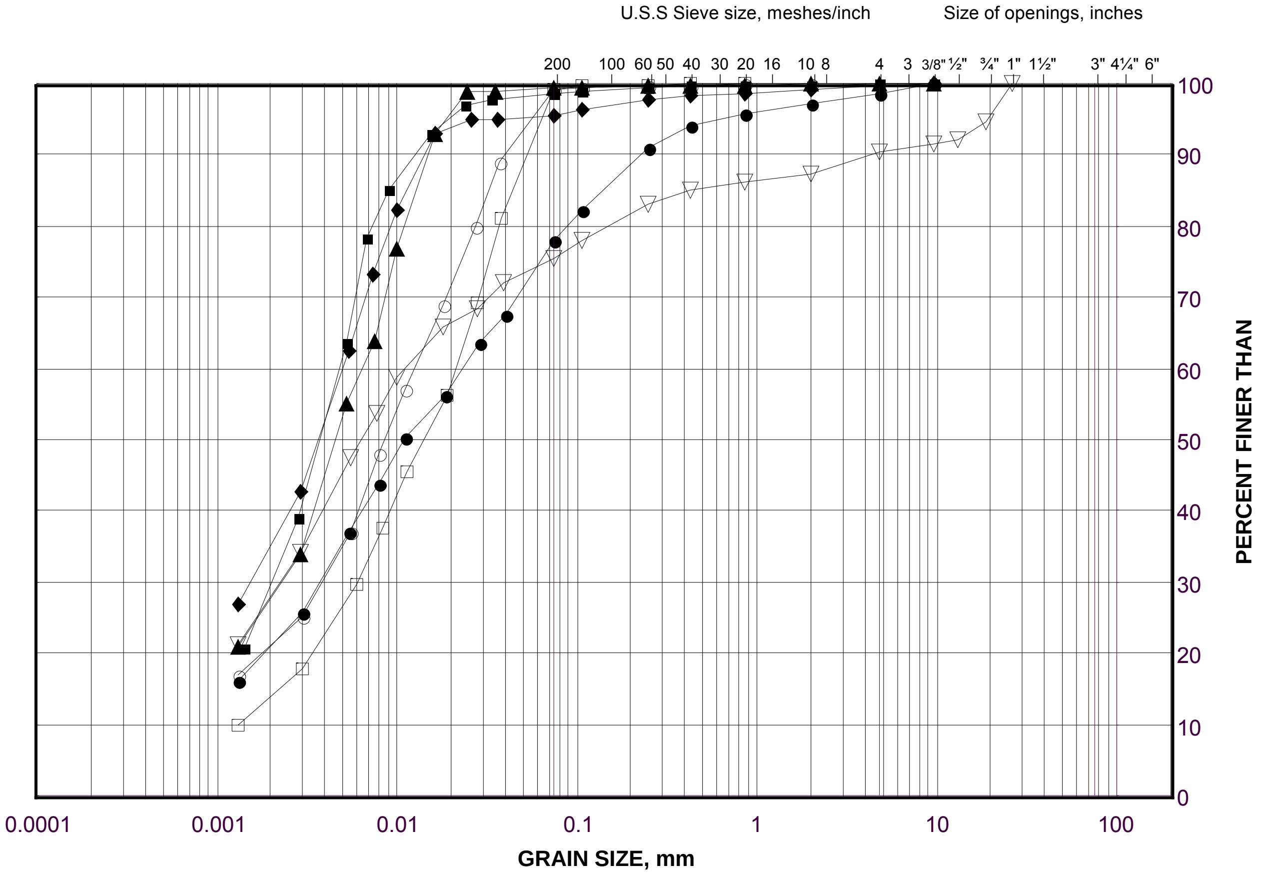
Golder Associates

Date: 08-Feb-13

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B3B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-7	12	208.2
■	SC-8	12	208.0
◆	12-7	13	206.4
▲	12-4	14	203.9
▽	12-9	16	199.4
❍	12-7	4	217.8
□	SC-8	4	217.9

Project Number: 09-1111-0018

Checked By: LCC

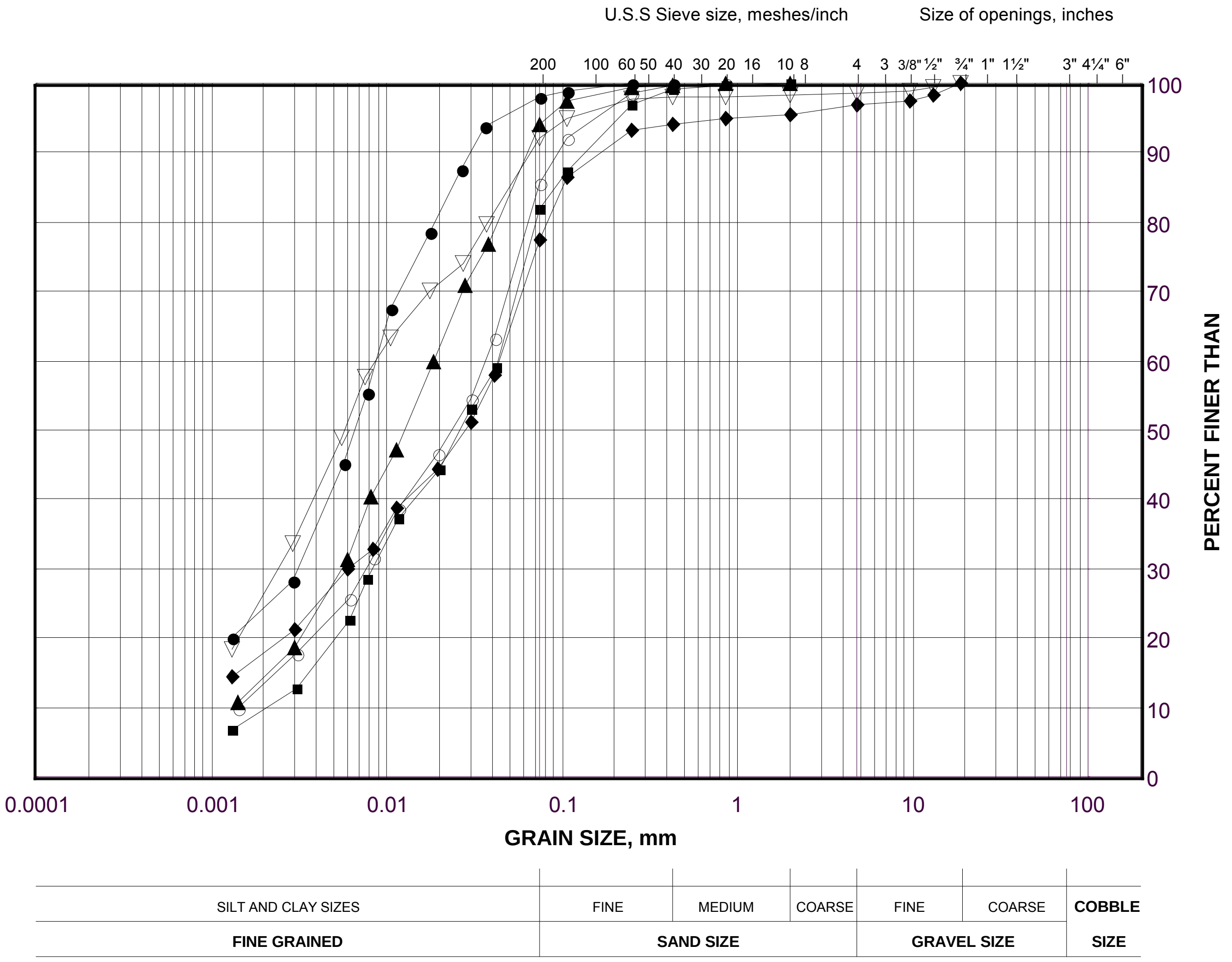
Golder Associates

Date: 25-Jan-13

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B3C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-4	5	216.2
■	BO-9	5	216.9
◆	12-6	6	215.6
▲	SC-7	6	216.7
▽	SC-5	6	216.2
❍	SC-8	8	214.1

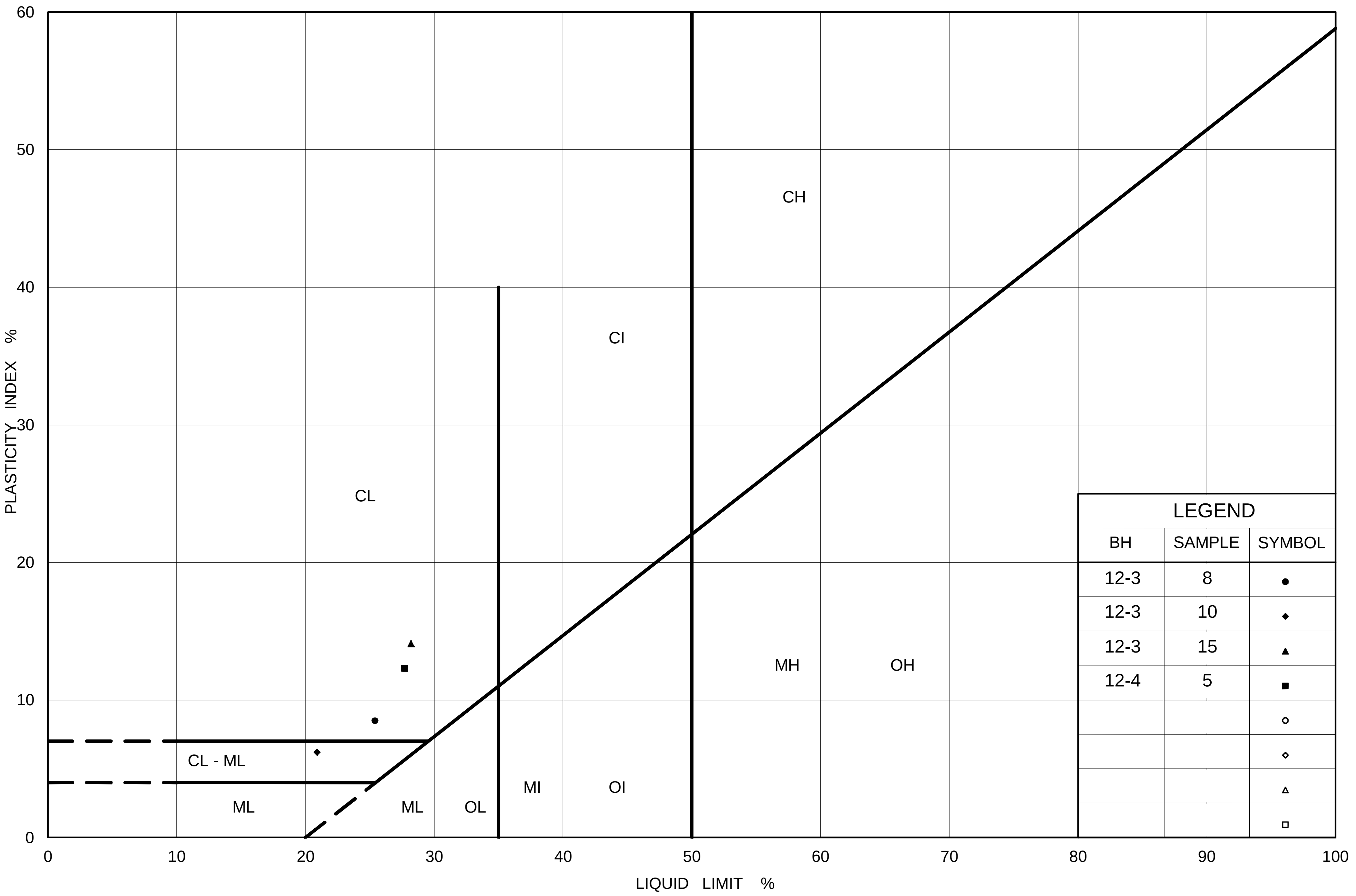
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 10-Jul-13

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
12-3	8	●
12-3	10	◆
12-3	15	▲
12-4	5	■
		○
		◇
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Ministry of Transportation

Ontario

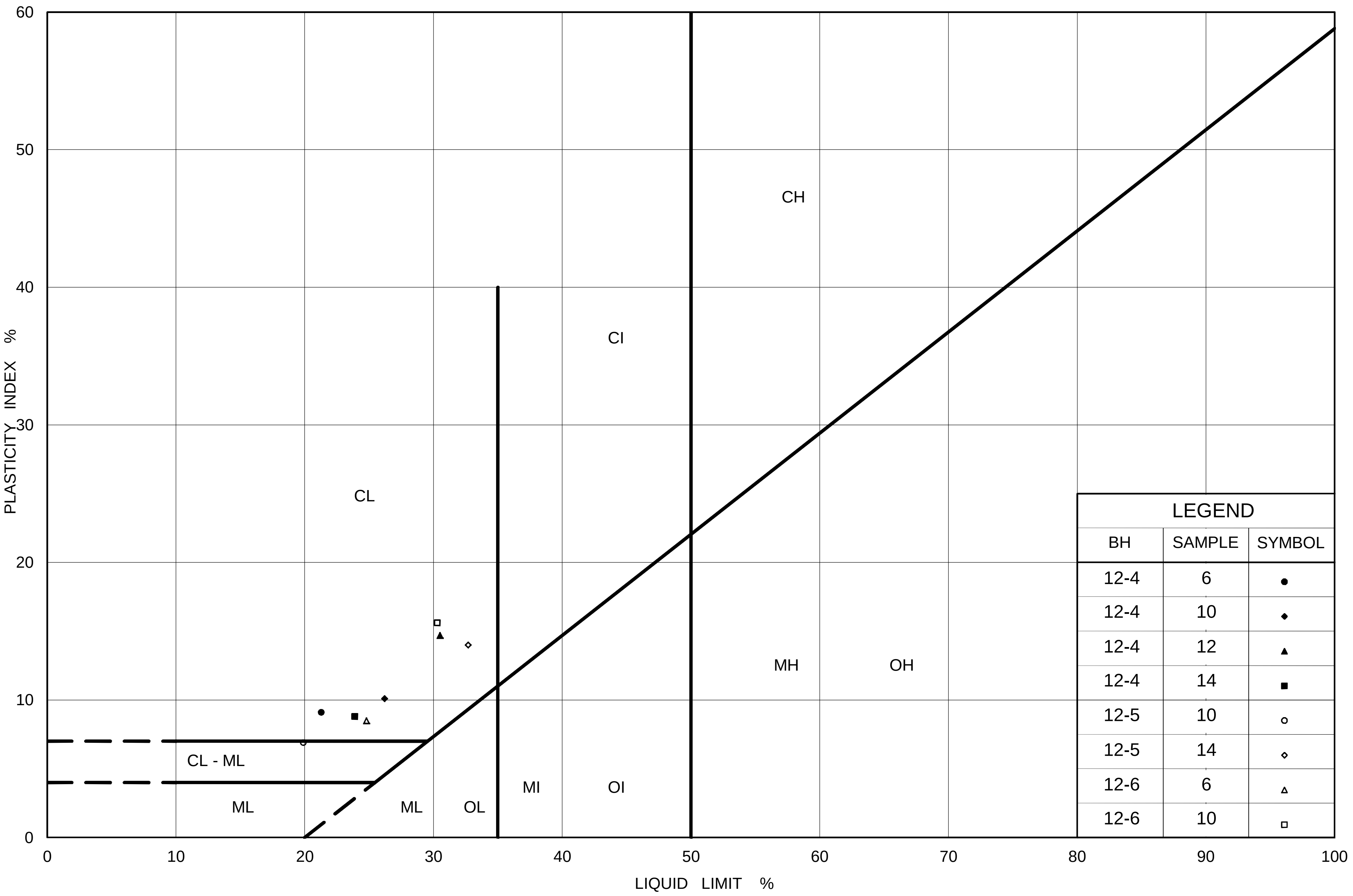
PLASTICITY CHART
Clayey Silt

Figure No. B4A

Project No. 09-1111-0018

Checked By: LCC

Oct 75, FF-S-21



Ministry of Transportation

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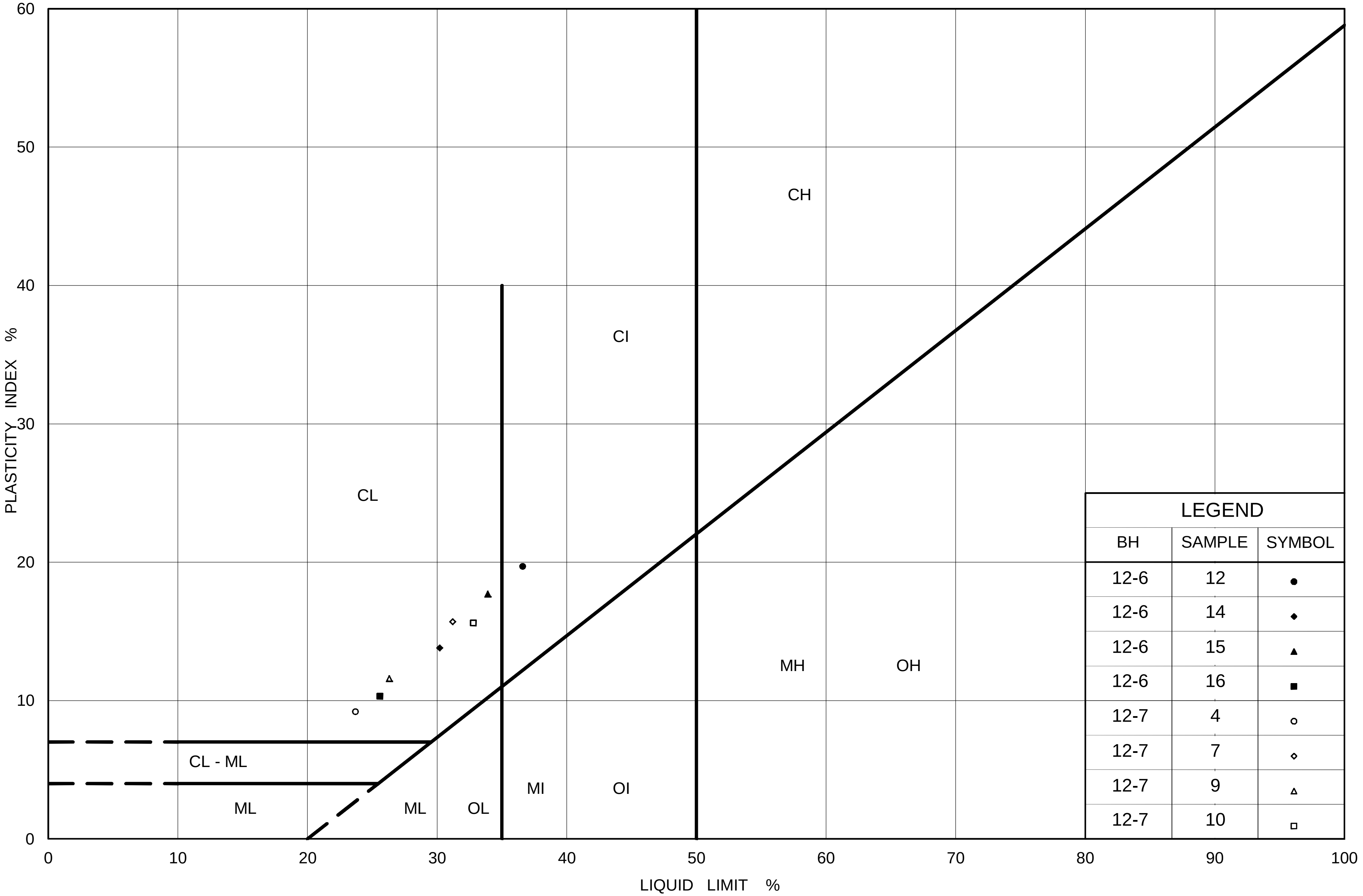
PLASTICITY CHART
Clayey Silt

Figure No. B4B

Project No. 09-1111-0018

Checked By: LCC

Oct 75, FF-S-21



Ministry of Transportation

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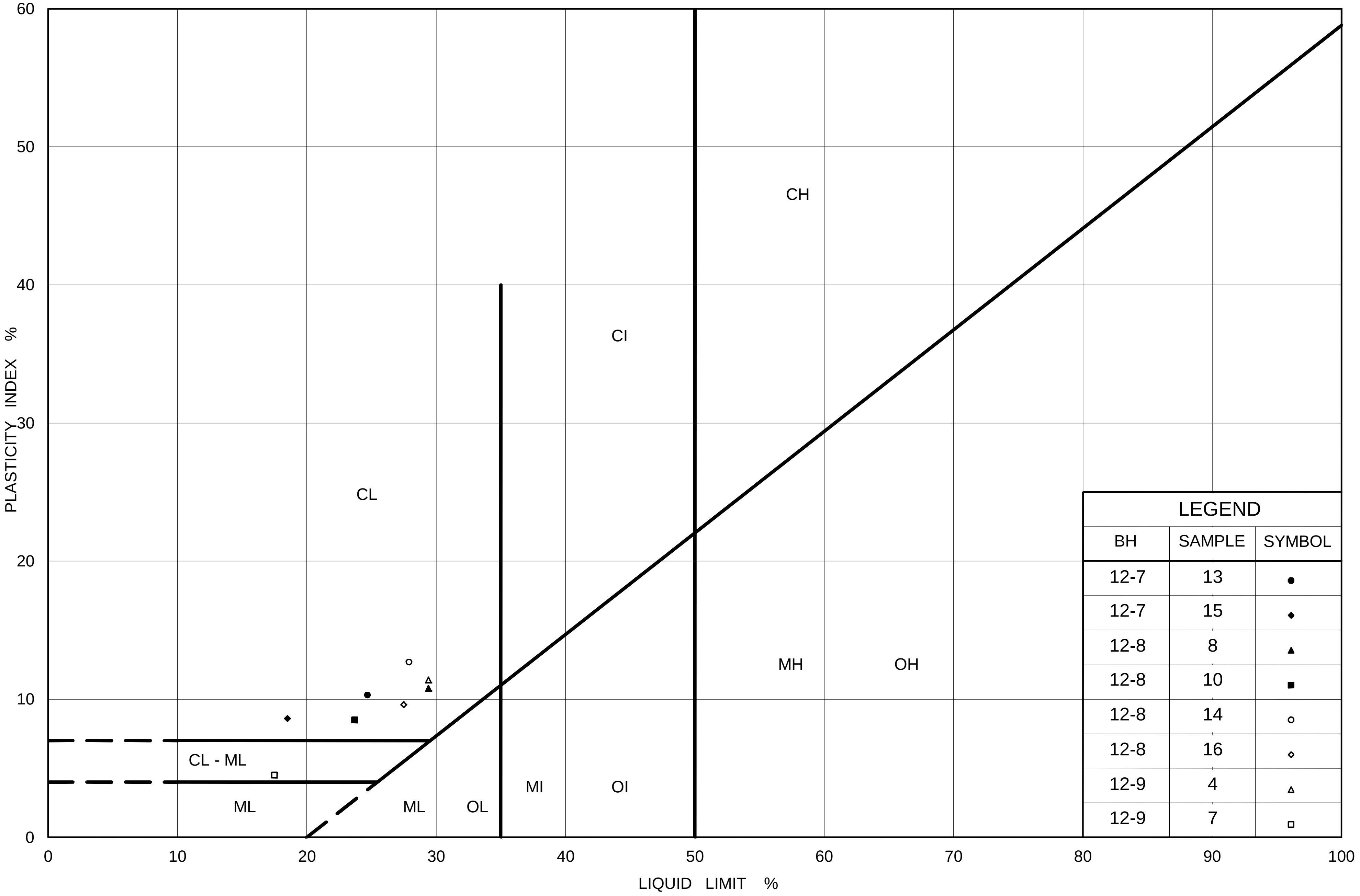
PLASTICITY CHART
Clayey Silt to Silty Clay

Figure No. B4C

Project No. 09-1111-0018

Checked By: LCC

Oct 75, FF-S-21



Ministry of Transportation

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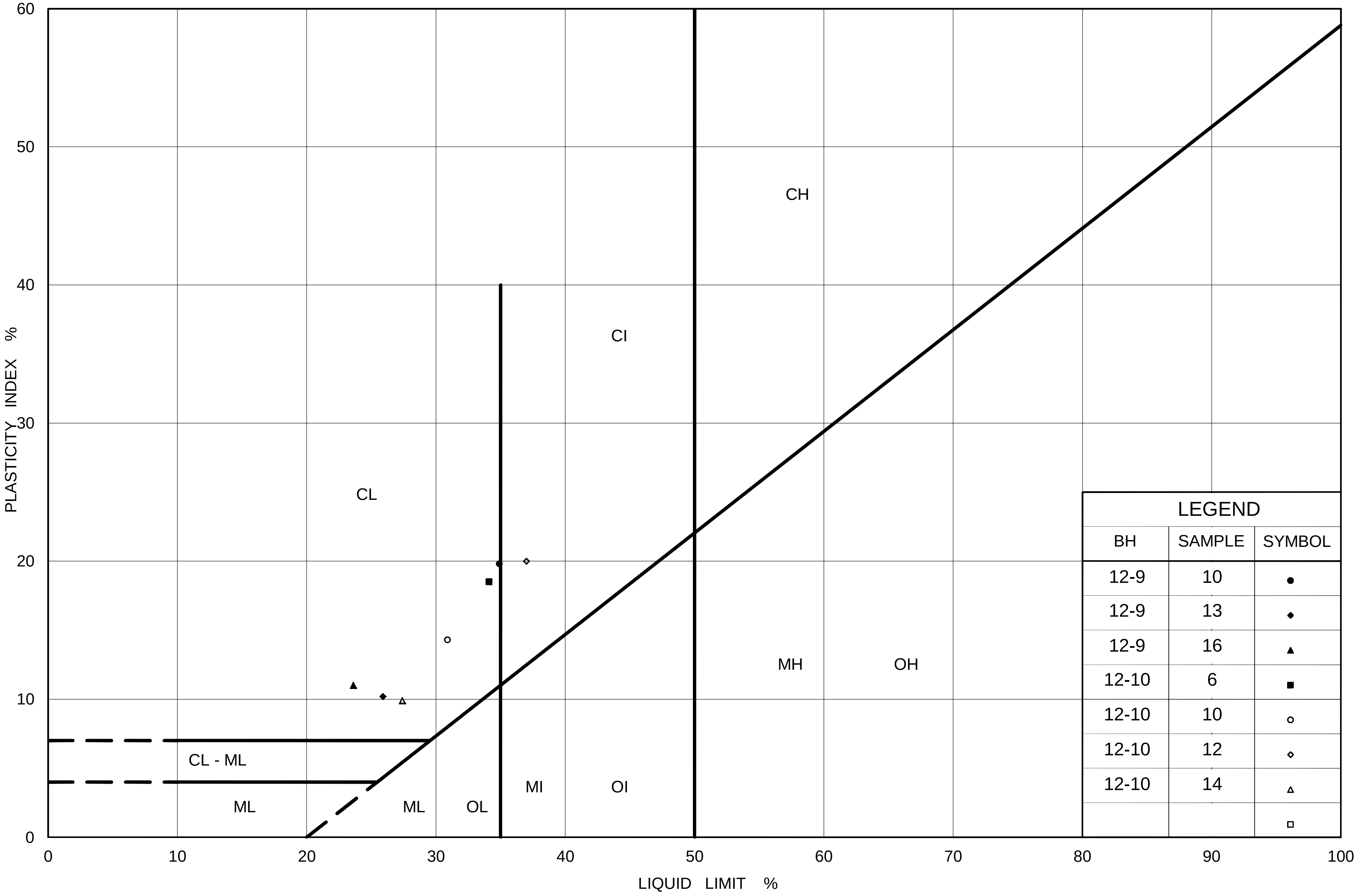
PLASTICITY CHART
Clayey Silt

Figure No. B4D

Project No. 09-1111-0018

Checked By: LCC

Oct 75, FF-S-21



Ministry of Transportation

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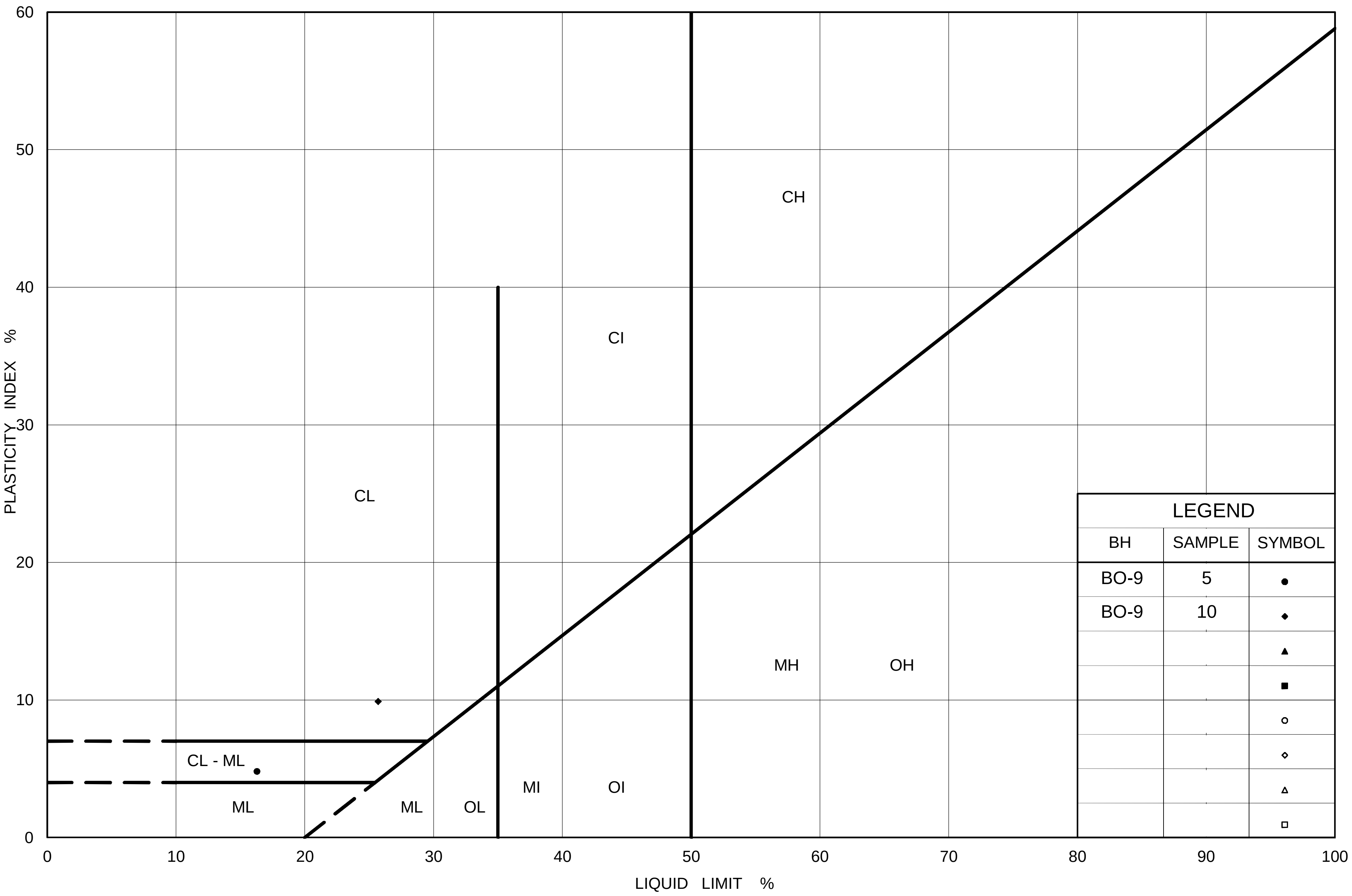
PLASTICITY CHART
Clayey Silt to Silty Clay

Figure No. B4E

Project No. 09-1111-0018

Checked By: LCC

Oct 75, FF-S-21



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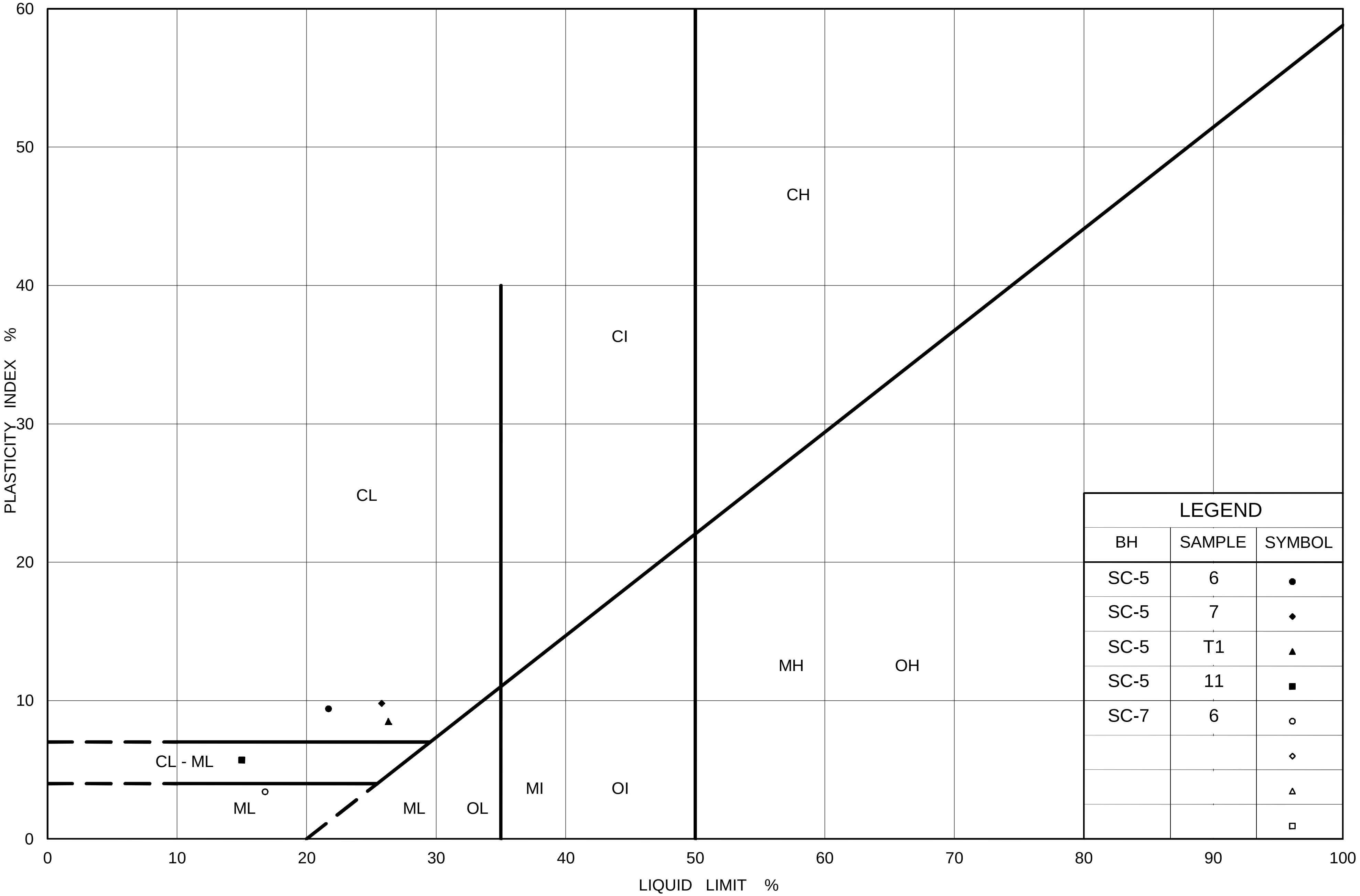
PLASTICITY CHART
Clayey Silt

Figure No. B4F

Project No. 09-1111-0018

Checked By: LCC

Oct 75, FF-S-21



BH	SAMPLE	SYMBOL
SC-5	6	●
SC-5	7	◆
SC-5	T1	▲
SC-5	11	■
SC-7	6	○
		◇
		△
		□

Ministry of Transportation

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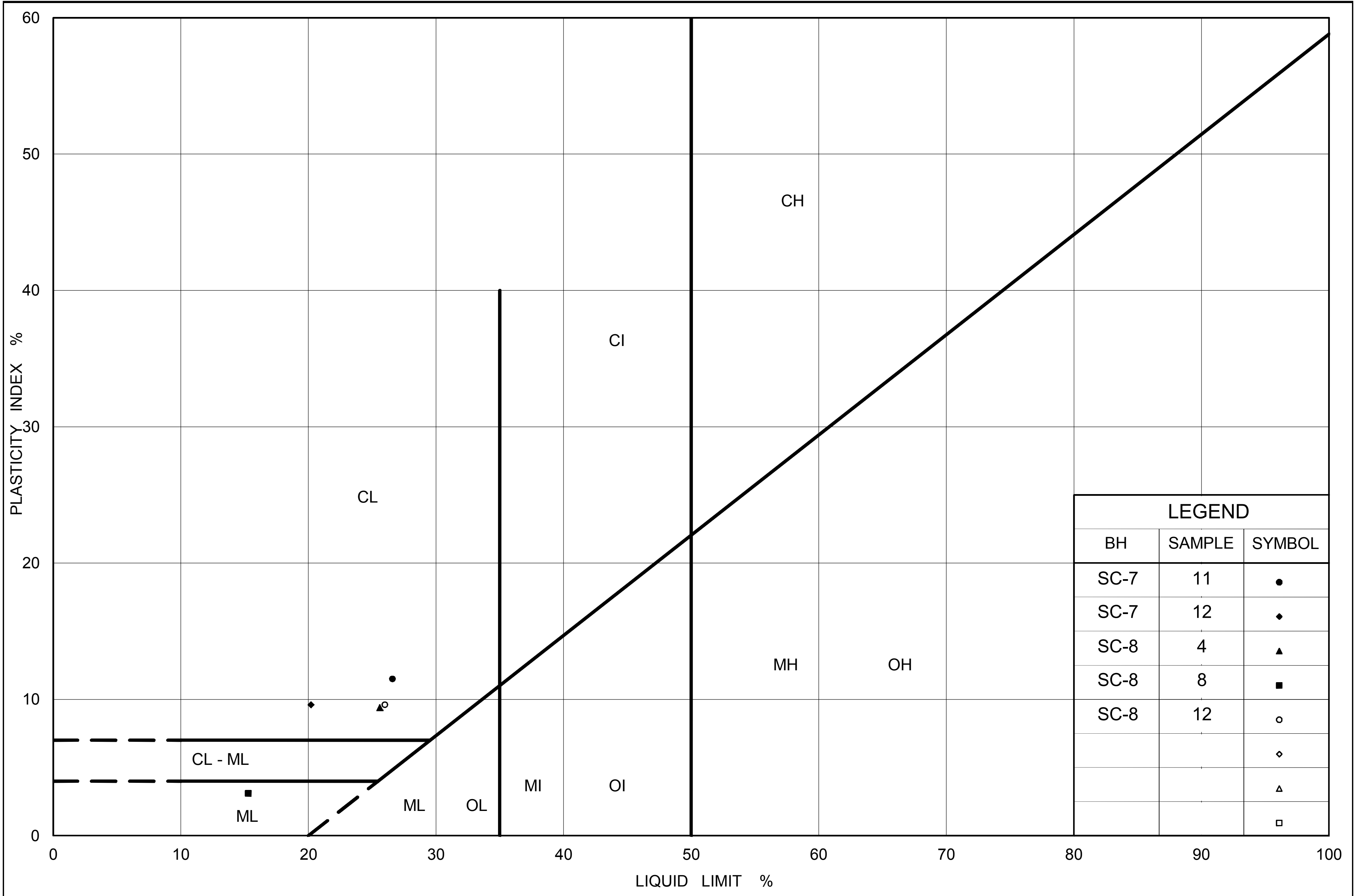
PLASTICITY CHART
Clayey Silt

Figure No. B4G

Project No. 09-1111-0018

Checked By: LCC

Oct 75, FF-S-21



Ministry of Transportation

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PLASTICITY CHART
Clayey Silt

Figure No. B4H

Project No. 09-1111-0018

Checked By: LCC

CONSOLIDATION TEST SUMMARY

FIGURE B5
Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-0018	Sample Number	6
Borehole Number	12-4	Sample Depth, m	3.81-4.27

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	11		
Date Started	06/11/2012		
Date Completed	06/25/2012		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.55	Unit Weight, kN/m^3	21.93
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	18.78
Area, cm^2	31.60	Specific Gravity, measured	2.75
Volume, cm^3	80.42	Solids Height, cm	1.772
Water Content, %	16.81	Volume of Solids, cm^3	55.99
Wet Mass, g	179.86	Volume of Voids, cm^3	24.43
Dry Mass, g	153.98	Degree of Saturation, %	105.9

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.545	0.436	2.545				
5.90	2.487	0.403	2.516	558	2.40E-03	3.88E-03	9.13E-07
10.61	2.476	0.397	2.481	1382	9.44E-04	9.43E-04	8.72E-08
20.43	2.463	0.390	2.469	1270	1.02E-03	4.92E-04	4.91E-08
39.84	2.443	0.379	2.453	1135	1.12E-03	4.09E-04	4.50E-08
78.69	2.419	0.365	2.431	714	1.75E-03	2.40E-04	4.12E-08
117.76	2.404	0.357	2.412	1058	1.17E-03	1.51E-04	1.72E-08
156.27	2.392	0.350	2.398	2233	5.46E-04	1.22E-04	6.55E-09
311.22	2.360	0.332	2.376	406	2.95E-03	8.29E-05	2.40E-08
620.94	2.323	0.311	2.341	470	2.47E-03	4.63E-05	1.12E-08
1240.62	2.286	0.290	2.304	265	4.25E-03	2.37E-05	9.85E-09
2489.67	2.245	0.267	2.266	277	3.93E-03	1.28E-05	4.92E-09
1240.62	2.246	0.268	2.246				
311.22	2.263	0.277	2.255				
78.69	2.279	0.286	2.271				
20.43	2.305	0.301	2.292				
5.90	2.321	0.310	2.313				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

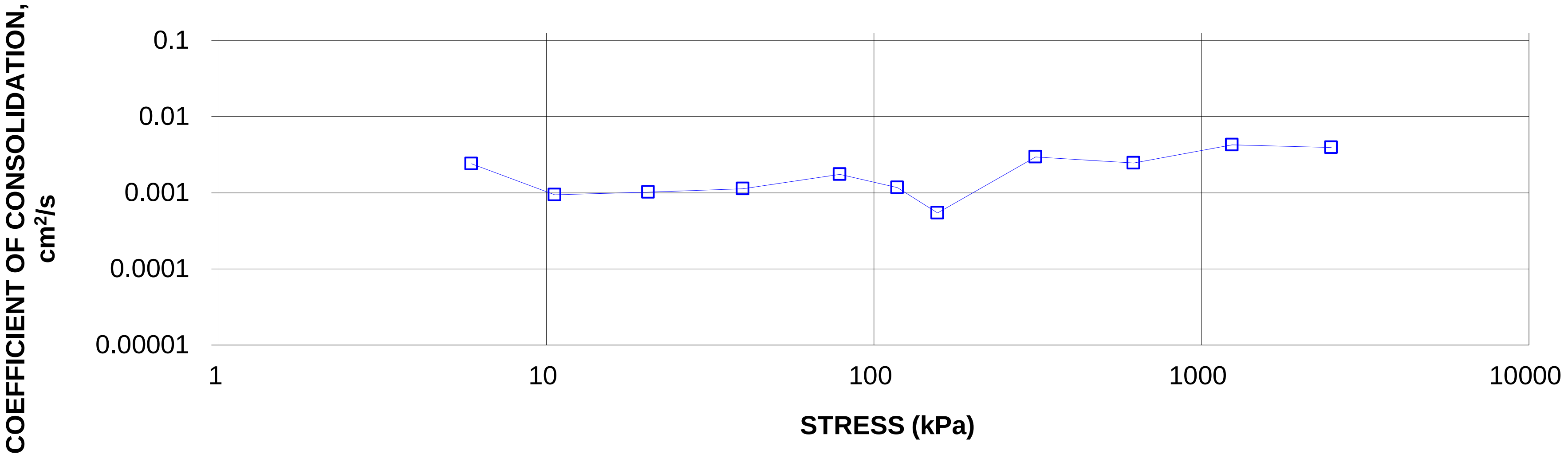
Sample Height, cm	2.32	Unit Weight, kN/m^3	23.41
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	20.59
Area, cm^2	31.60	Specific Gravity, measured	2.75
Volume, cm^3	73.35	Solids Height, cm	1.772
Water Content, %	13.73	Volume of Solids, cm ^{3}	55.99
Wet Mass, g	175.12	Volume of Voids, cm ^{3}	17.36
Dry Mass, g	153.98		

Prepared By: LH **Golder Associates** Checked By: LCC

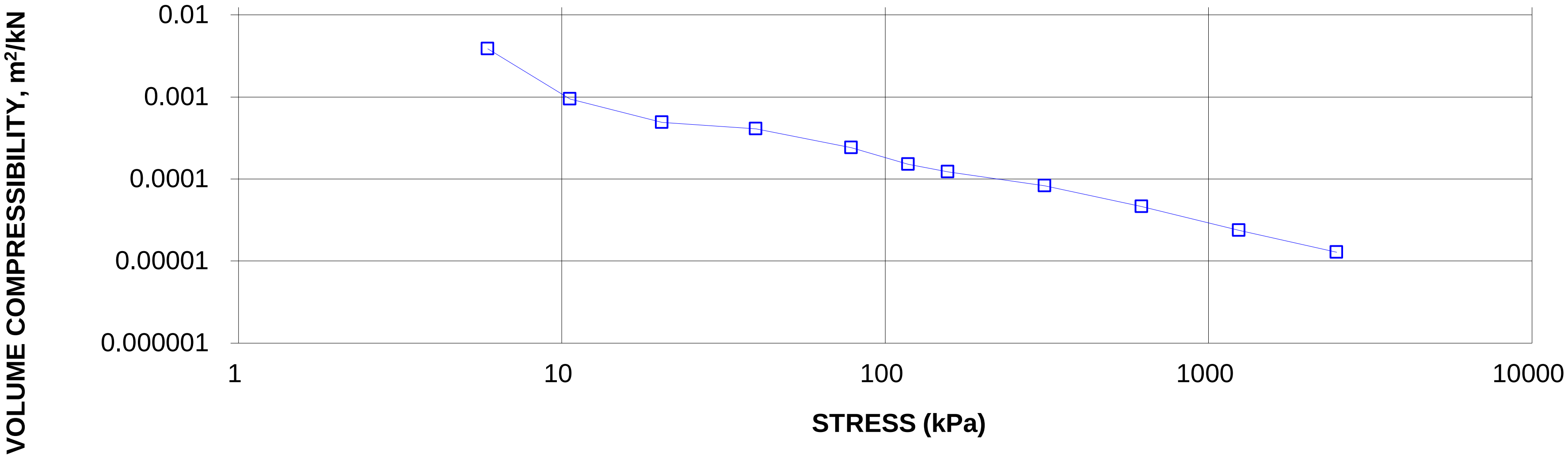
CONSOLIDATION TEST SUMMARY

FIGURE B5
Sheet 2 of 4

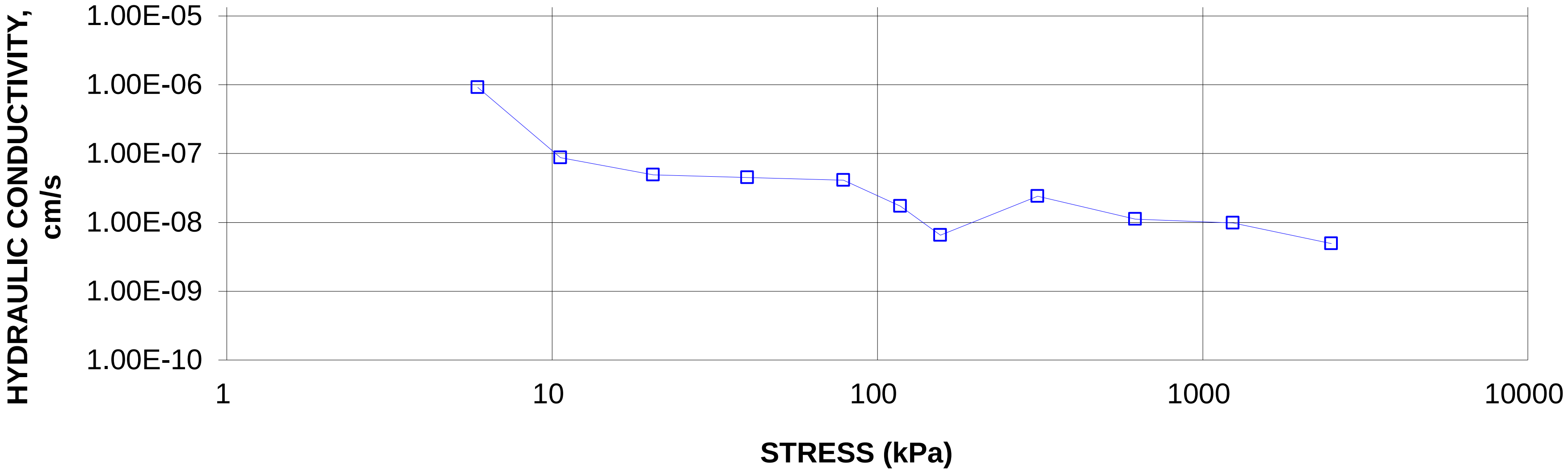
CONSOLIDATION TEST
CV cm^2/s VS STRESS (kPa)
BH 12-4 SA 6



CONSOLIDATION TEST
MV m^2/kN vs STRESS (kPa)
BH 12-4 SA 6



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH 12-4 SA 6



Project No. 09-1111-0018
Prepared By: LH

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Project No. 09-1111-0018

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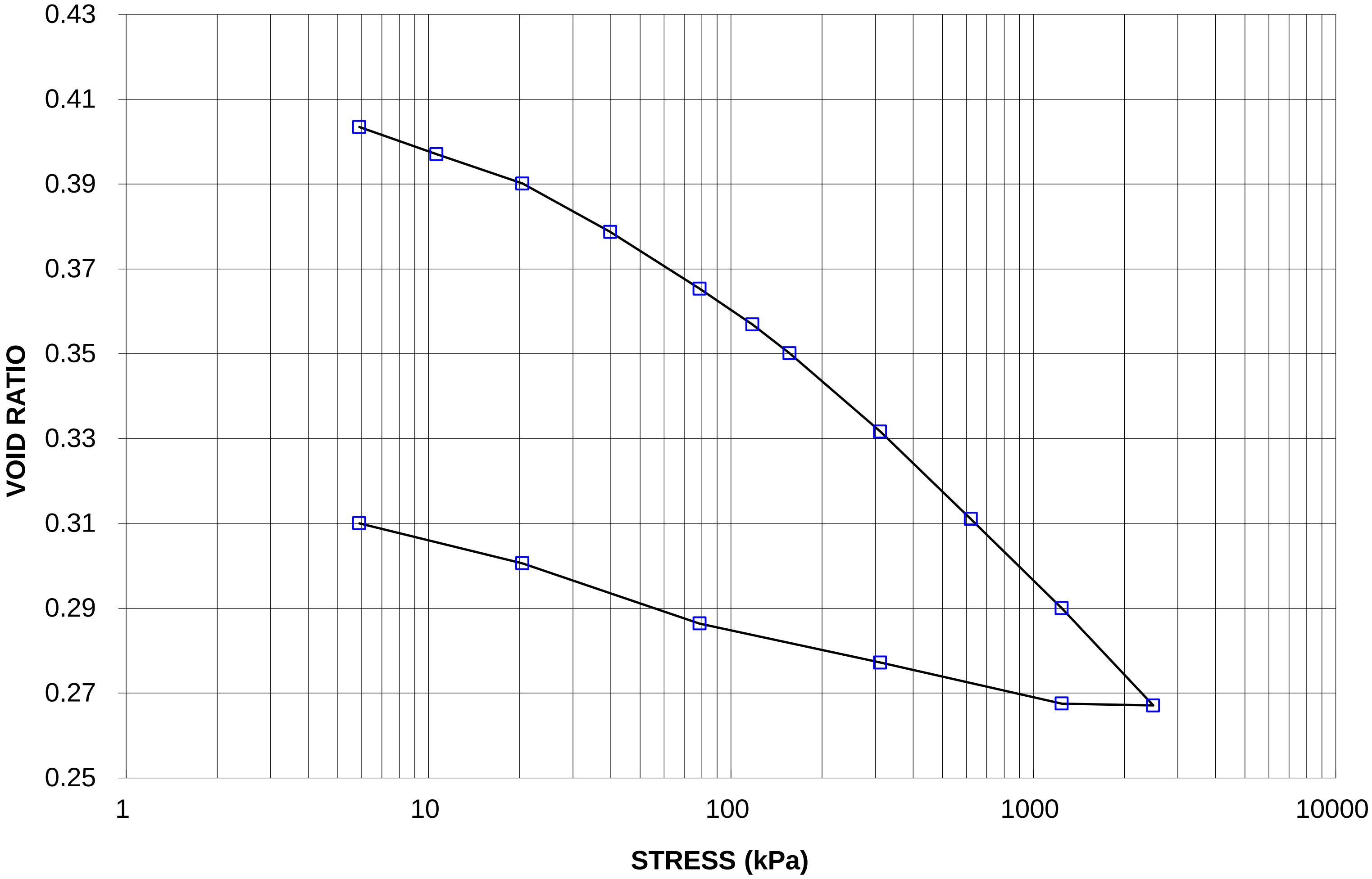
CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 12-4 SA 6



CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE B5
Sheet 3 of 4

Project No. 09-1111-0018

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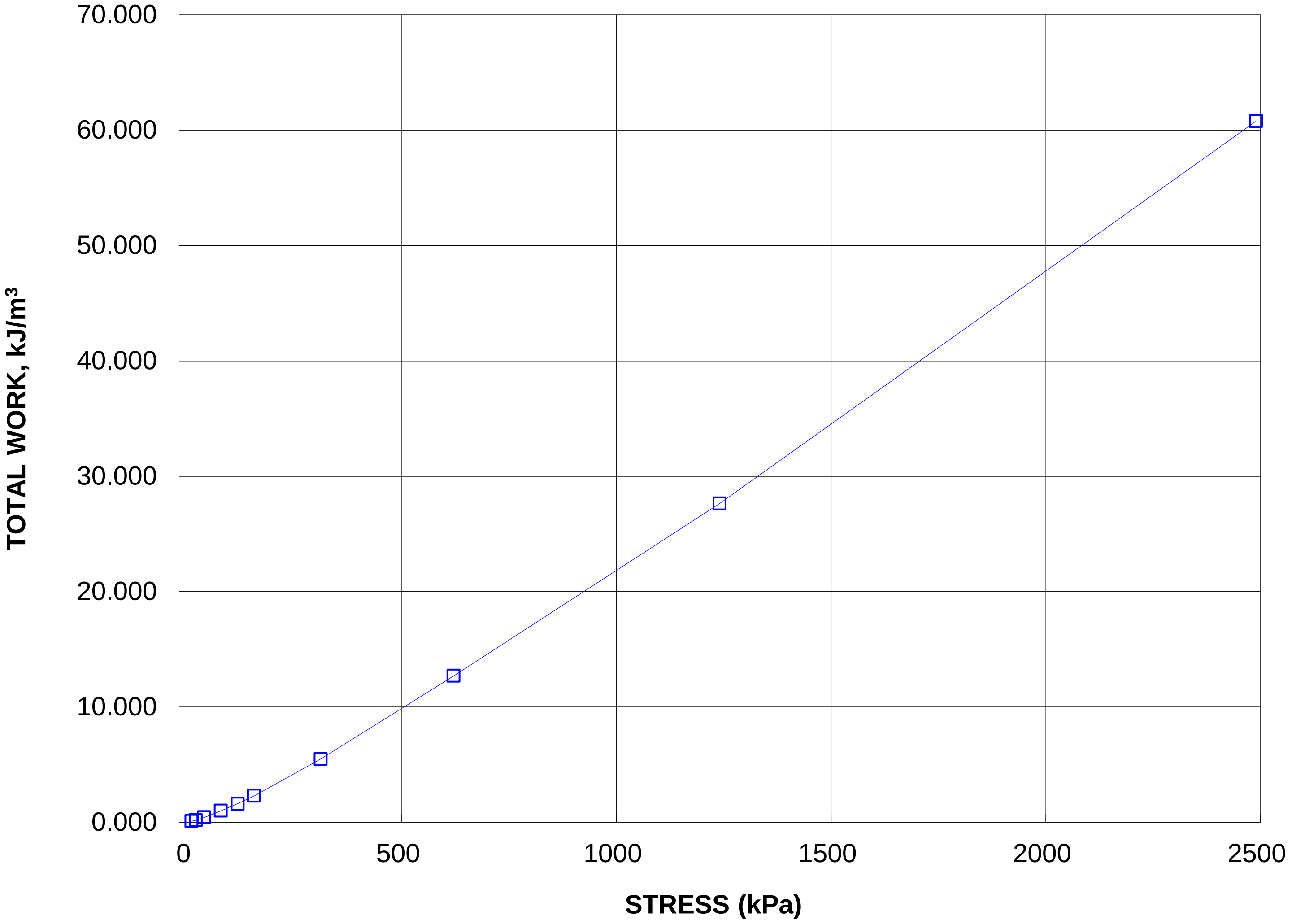
CONSOLIDATION TEST
TOTAL WORK, kJ/m³ vs STRESS
BH12-4 SA 6



CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE B5
Sheet 4 of 4

CONSOLIDATION TEST SUMMARY

FIGURE B6
Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-0018	Sample Number	15
Borehole Number	12-6	Sample Depth, m	16.01-16.62

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	4		
Date Started	06/11/2012		
Date Completed	06/28/2012		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.54	Unit Weight, kN/m^3	18.28
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	13.28
Area, cm^2	31.53	Specific Gravity, measured	2.78
Volume, cm^3	80.02	Solids Height, cm	1.237
Water Content, %	37.63	Volume of Solids, cm^3	38.99
Wet Mass, g	149.18	Volume of Voids, cm^3	41.03
Dry Mass, g	108.39	Degree of Saturation, %	99.4

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.538	1.052	2.538				
6.11	2.533	1.049	2.536	390	3.49E-03	3.10E-04	1.06E-07
10.97	2.528	1.044	2.530	634	2.14E-03	4.62E-04	9.70E-08
20.76	2.517	1.035	2.522	778	1.73E-03	4.31E-04	7.32E-08
40.25	2.497	1.019	2.507	290	4.59E-03	4.00E-04	1.80E-07
79.12	2.468	0.996	2.483	558	2.34E-03	2.93E-04	6.72E-08
117.90	2.444	0.977	2.456	2458	5.20E-04	2.41E-04	1.23E-08
156.77	2.423	0.959	2.434	3241	3.87E-04	2.20E-04	8.35E-09
312.68	2.315	0.872	2.369	1058	1.12E-03	2.73E-04	3.01E-08
623.18	2.150	0.739	2.232	1033	1.02E-03	2.09E-04	2.09E-08
1243.60	2.030	0.641	2.090	778	1.19E-03	7.65E-05	8.92E-09
2475.35	1.929	0.560	1.979	470	1.77E-03	3.20E-05	5.55E-09
1243.60	1.935	0.565	1.932				
312.68	1.973	0.596	1.954				
79.12	2.020	0.633	1.996				
20.76	2.065	0.670	2.042				
6.27	2.105	0.703	2.085				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	2.11	Unit Weight, kN/m^3	20.19
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	16.01
Area, cm^2	31.53	Specific Gravity, measured	2.78
Volume, cm^3	66.38	Solids Height, cm	1.237
Water Content, %	26.09	Volume of Solids, cm ^{3}	38.99
Wet Mass, g	136.67	Volume of Voids, cm ^{3}	27.39
Dry Mass, g	108.39		

Prepared By: LH

Golder Associates

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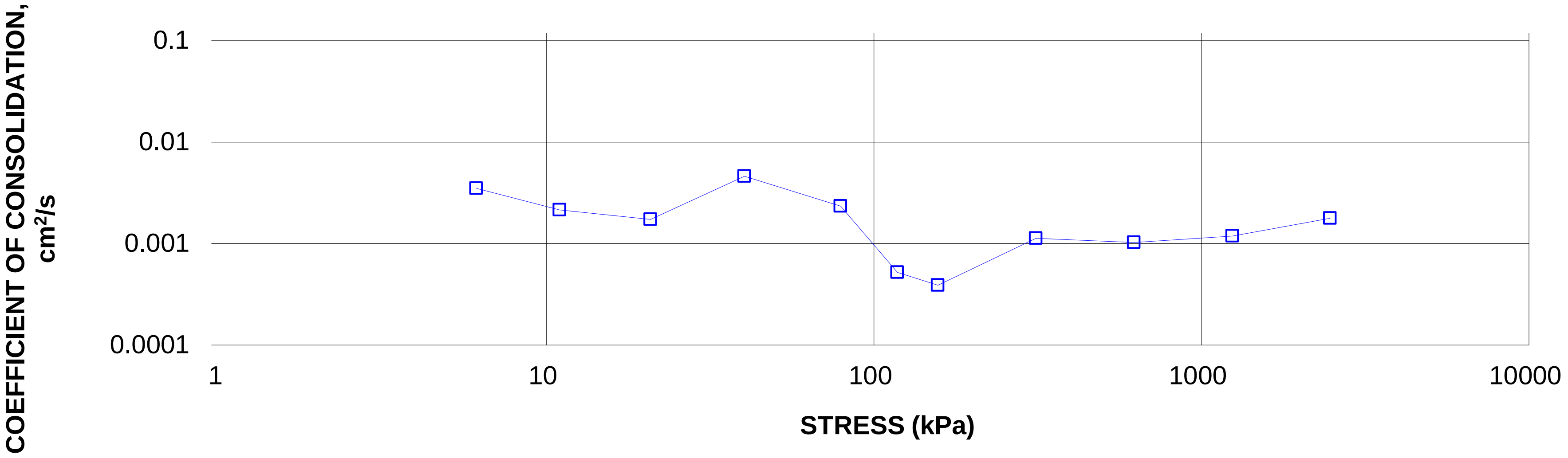
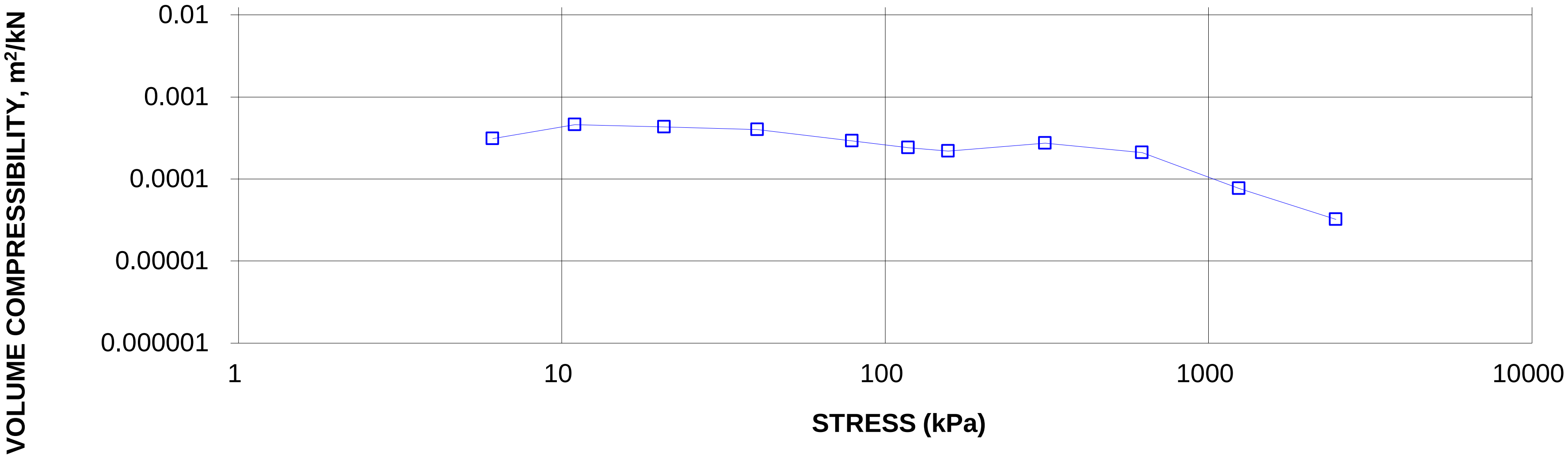
CONSOLIDATION TEST SUMMARY

FIGURE B6
Sheet 2 of 4

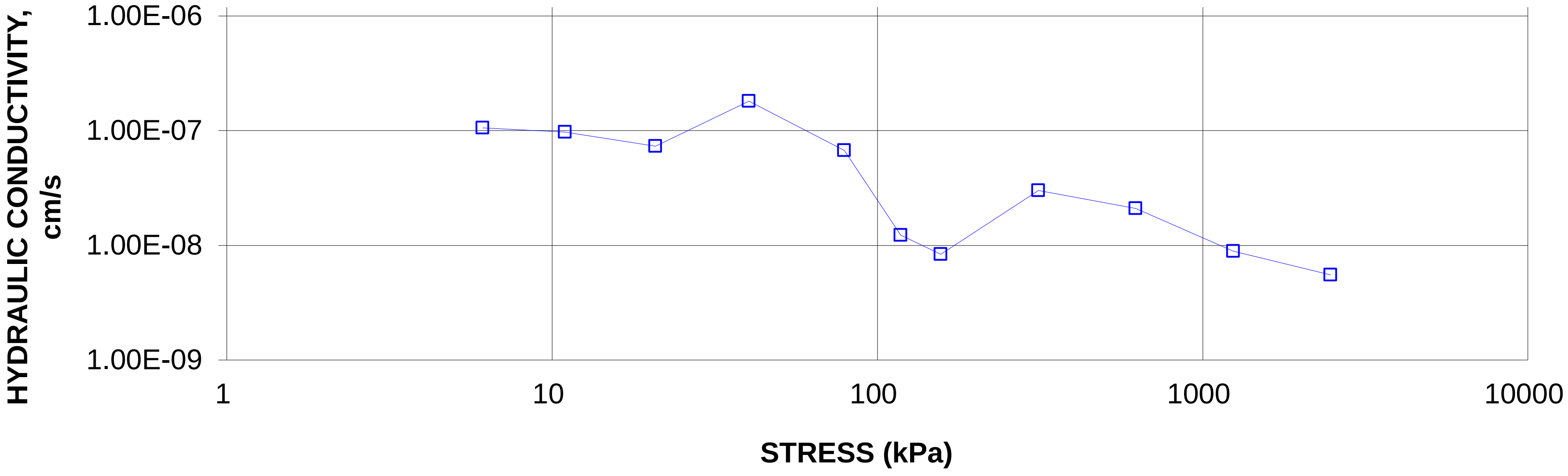
CONSOLIDATION TEST
CV cm^2/s VS STRESS (kPa)
BH 12-6 SA 15



CONSOLIDATION TEST
MV m^2/kN vs STRESS (kPa)
BH 12-6 SA 15



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH 12-6 SA 15



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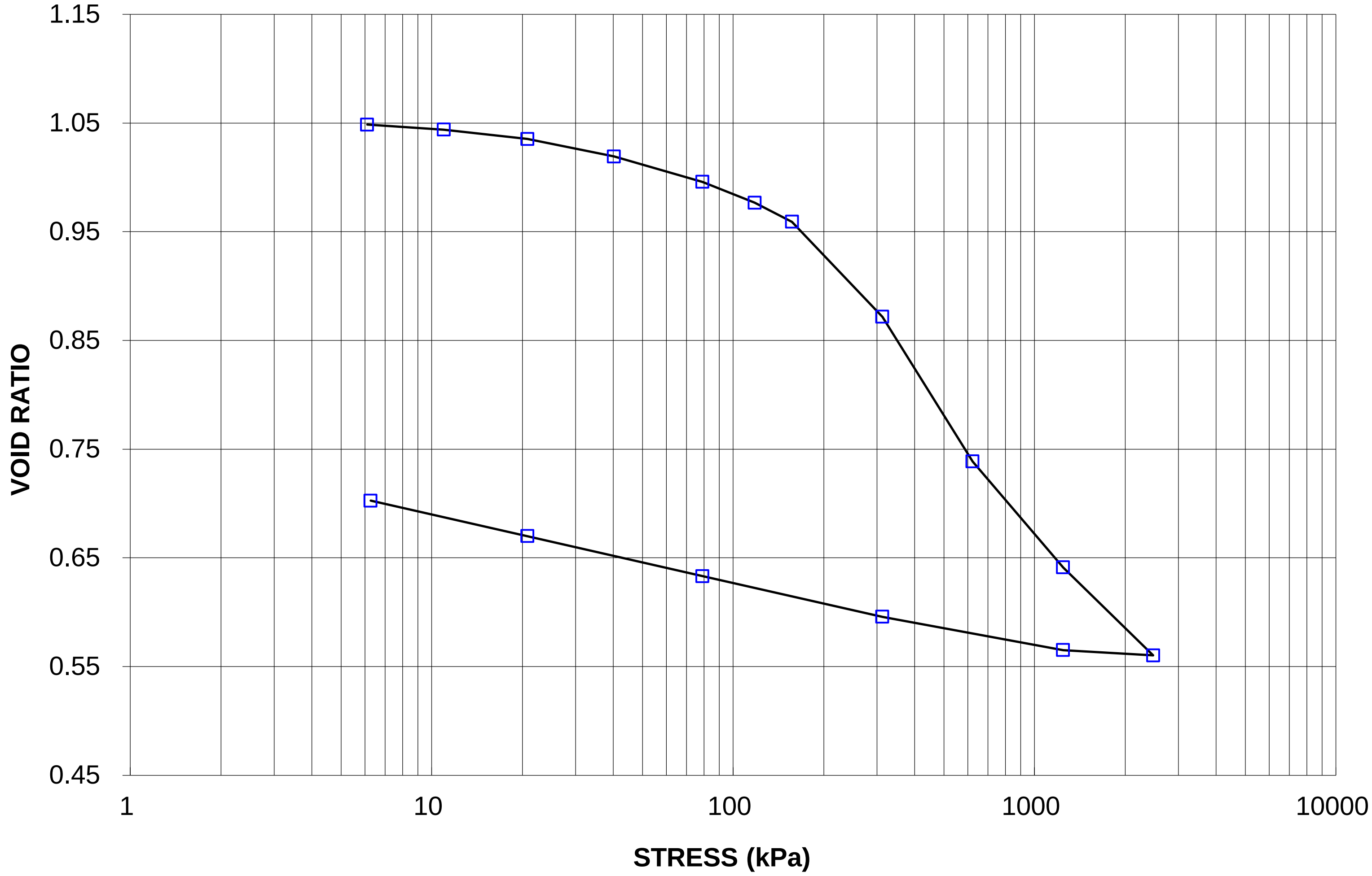
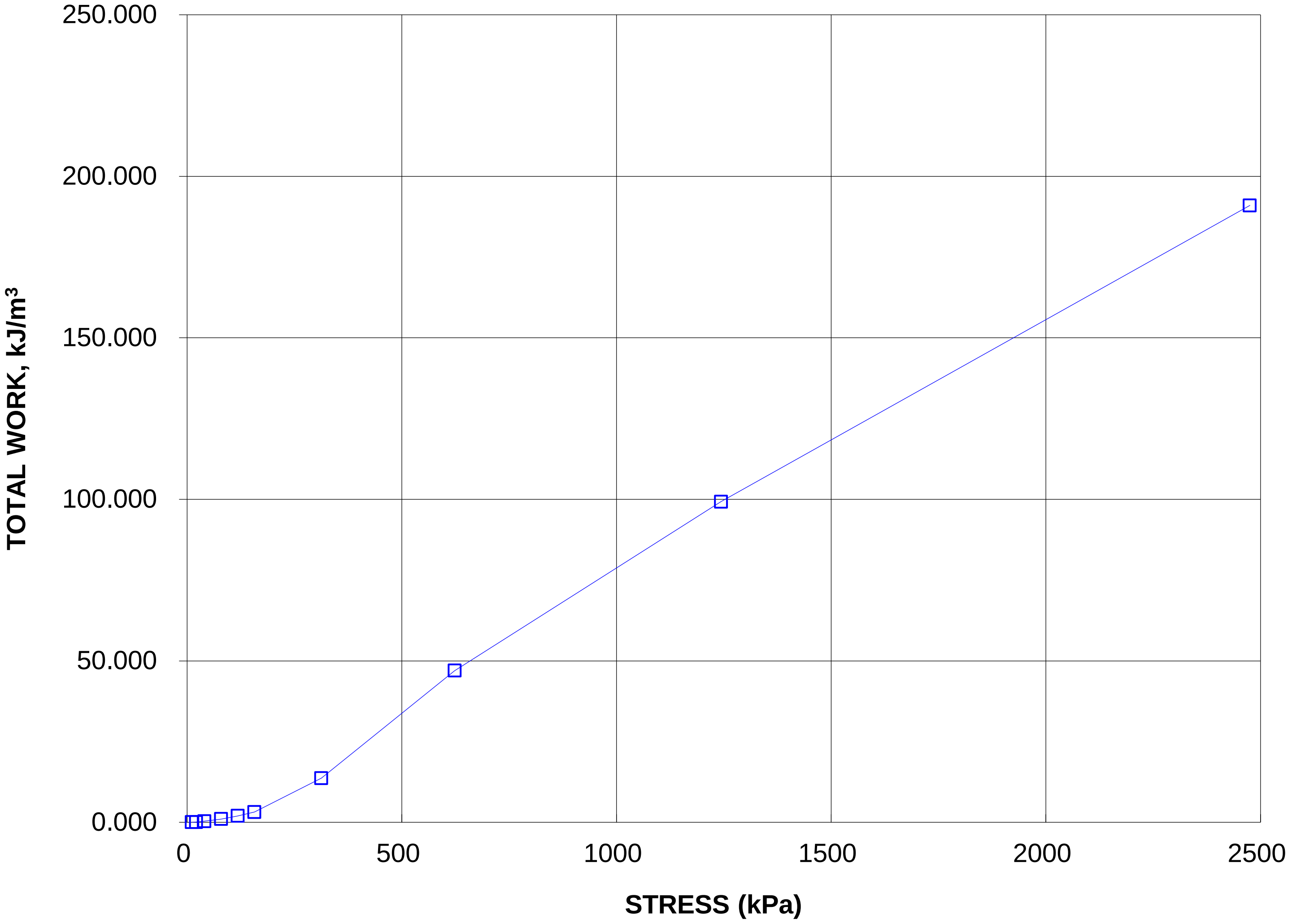
CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 12-6 SA 15



CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE B6
Sheet 3 of 4

CONSOLIDATION TEST
TOTAL WORK, kJ/m³ vs STRESS
BH12-6 SA 15



Project No. 09-1111-0018

Prepared By: LH

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CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE B6
Sheet 4 of 4

CONSOLIDATION TEST SUMMARY

FIGURE B7
Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-0018	Sample Number	10
Borehole Number	12-7	Sample Depth, m	9.76-10.21

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	2		
Date Started	06/11/2012		
Date Completed	06/25/2012		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.54	Unit Weight, kN/m^3	19.37
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	15.03
Area, cm^2	31.58	Specific Gravity, measured	2.77
Volume, cm^3	80.09	Solids Height, cm	1.403
Water Content, %	28.92	Volume of Solids, cm^3	44.30
Wet Mass, g	158.20	Volume of Voids, cm^3	35.79
Dry Mass, g	122.71	Degree of Saturation, %	99.2

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.536	0.808	2.536				
5.95	2.529	0.803	2.533	290	4.69E-03	4.57E-04	2.10E-07
10.75	2.521	0.797	2.525	913	1.48E-03	6.33E-04	9.18E-08
20.72	2.510	0.789	2.516	821	1.63E-03	4.51E-04	7.22E-08
40.16	2.491	0.776	2.500	595	2.23E-03	3.87E-04	8.46E-08
78.90	2.467	0.758	2.479	487	2.67E-03	2.47E-04	6.48E-08
117.96	2.448	0.745	2.457	1162	1.10E-03	1.92E-04	2.07E-08
156.24	2.432	0.733	2.440	2160	5.84E-04	1.64E-04	9.38E-09
312.03	2.368	0.688	2.400	540	2.26E-03	1.61E-04	3.58E-08
621.92	2.269	0.618	2.319	558	2.04E-03	1.26E-04	2.52E-08
1242.60	2.183	0.556	2.226	454	2.31E-03	5.49E-05	1.24E-08
2487.10	2.103	0.499	2.143	437	2.23E-03	2.54E-05	5.54E-09
1242.56	2.104	0.500	2.103				
312.03	2.127	0.516	2.116				
78.90	2.151	0.533	2.139				
20.72	2.185	0.558	2.168				
5.95	2.206	0.573	2.196				

Note:
k calculated using cv based on t_{90} values.

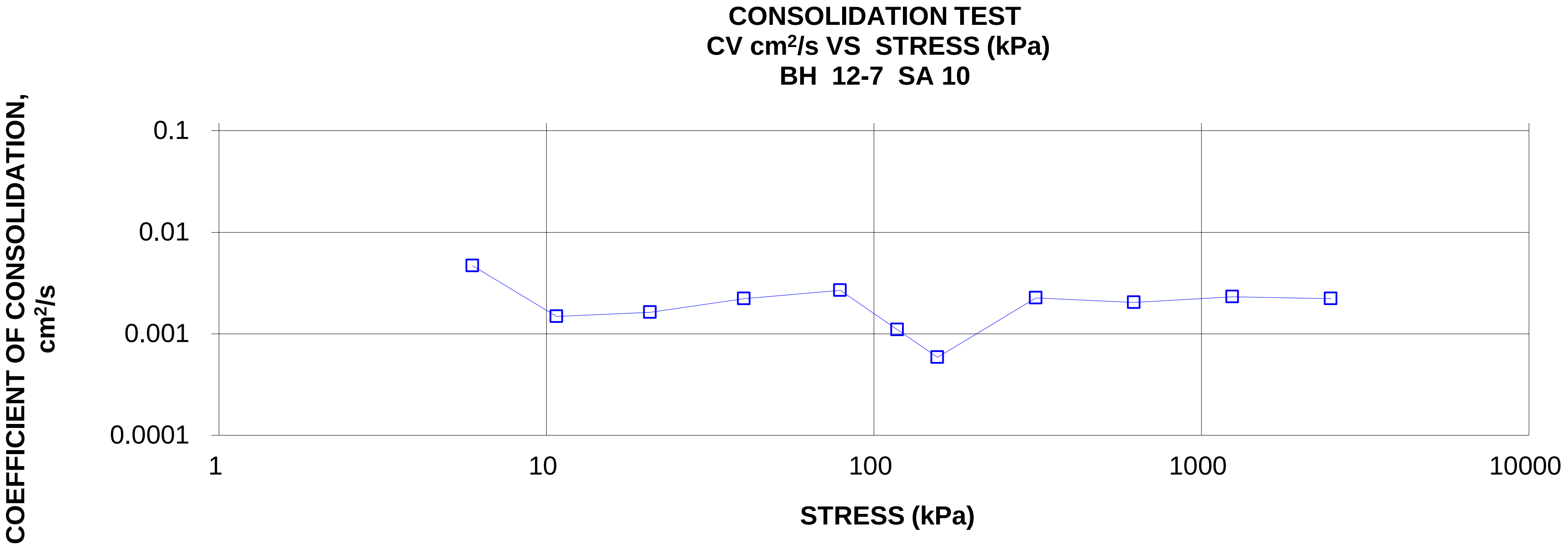
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

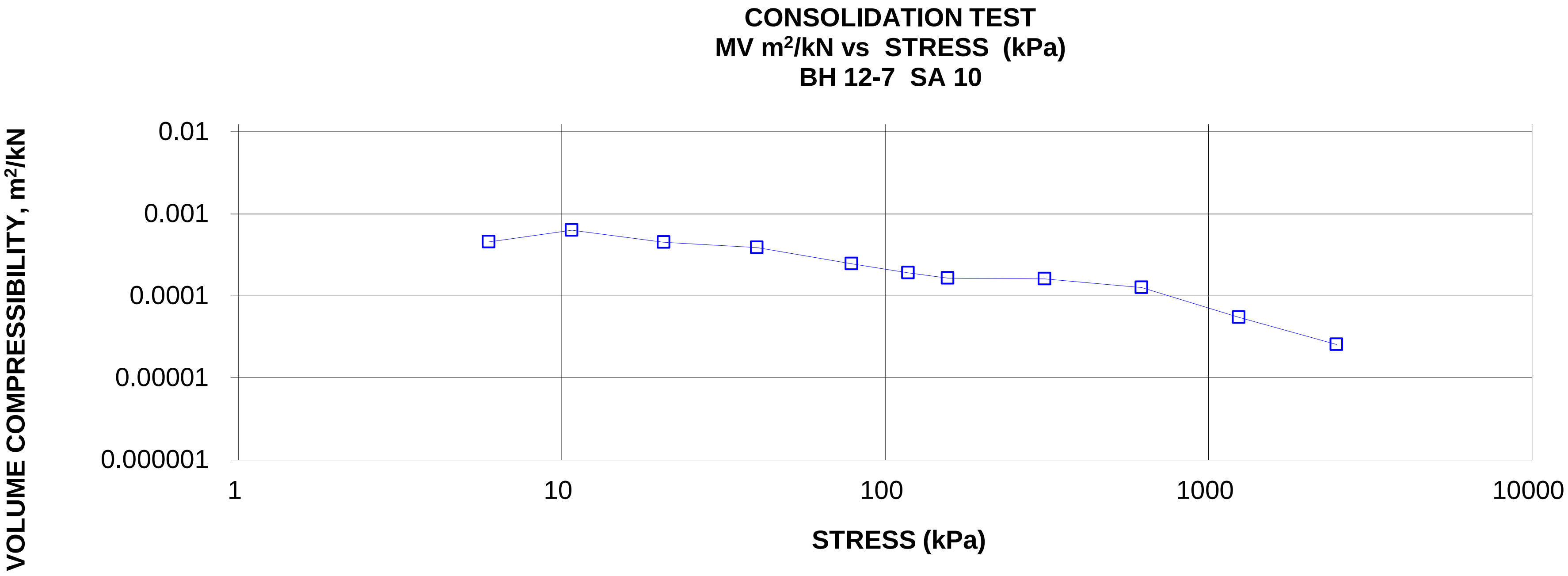
Sample Height, cm	2.21	Unit Weight, kN/m^3	21.02
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	17.27
Area, cm^2	31.58	Specific Gravity, measured	2.77
Volume, cm^3	69.67	Solids Height, cm	1.403
Water Content, %	21.69	Volume of Solids, cm ^{3}	44.30
Wet Mass, g	149.32	Volume of Voids, cm ^{3}	25.37
Dry Mass, g	122.71		

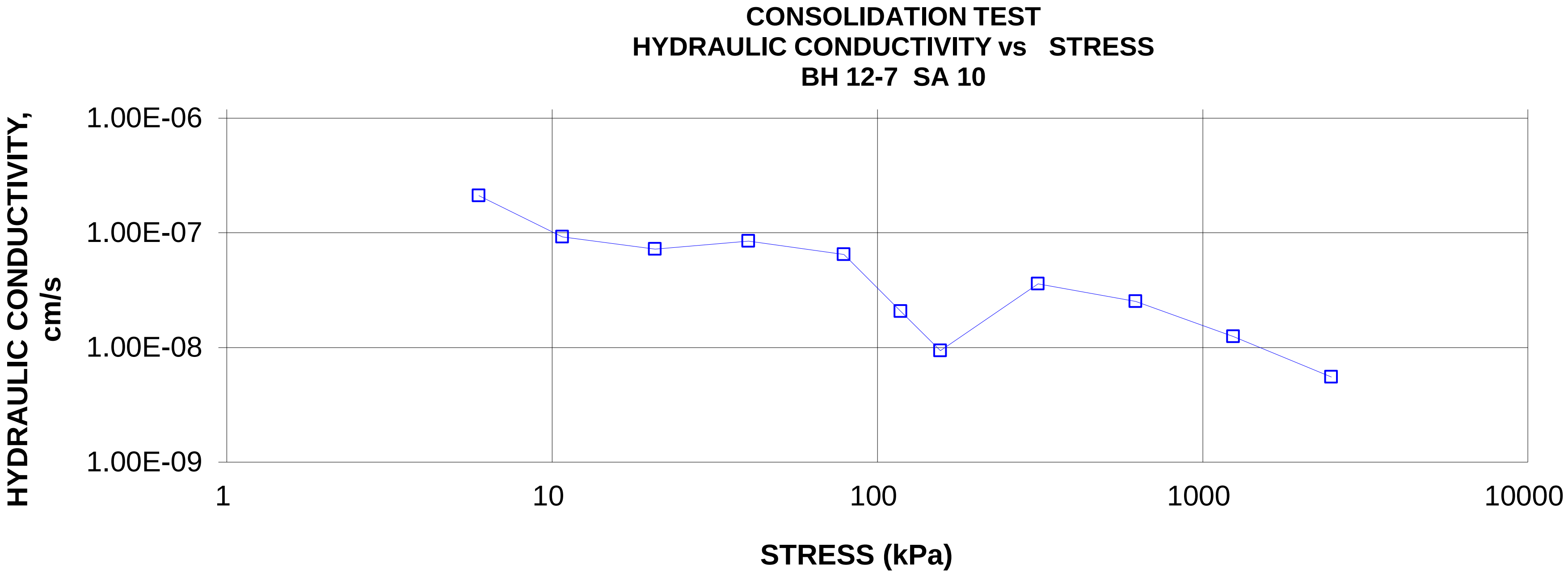
Prepared By: LH **Golder Associates** Checked By: LCC

CONSOLIDATION TEST SUMMARY

FIGURE B7
Sheet 2 of 4







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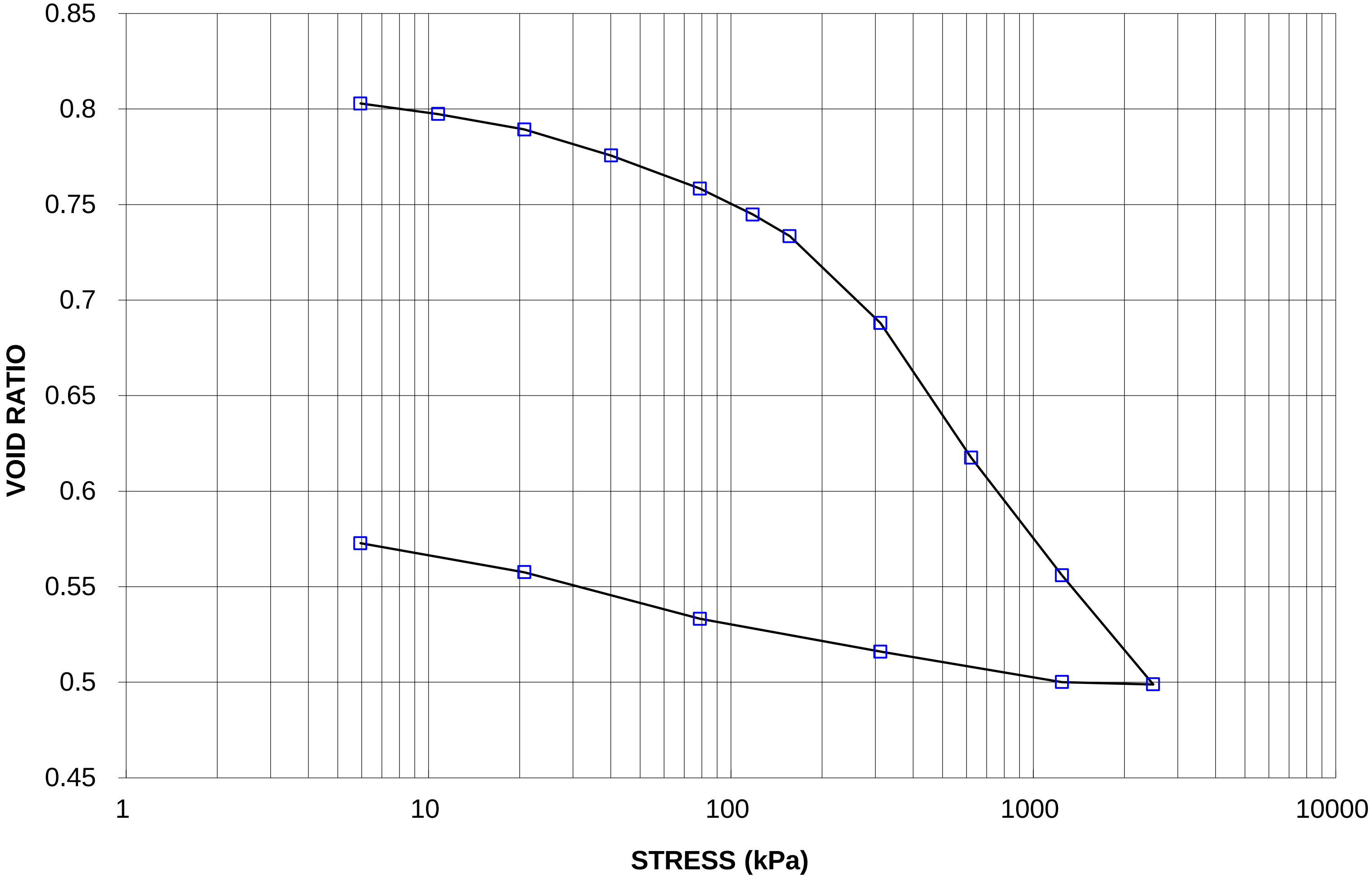
CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 12-7 SA 10



CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE B7
Sheet 3 of 4

Project No. 09-1111-0018

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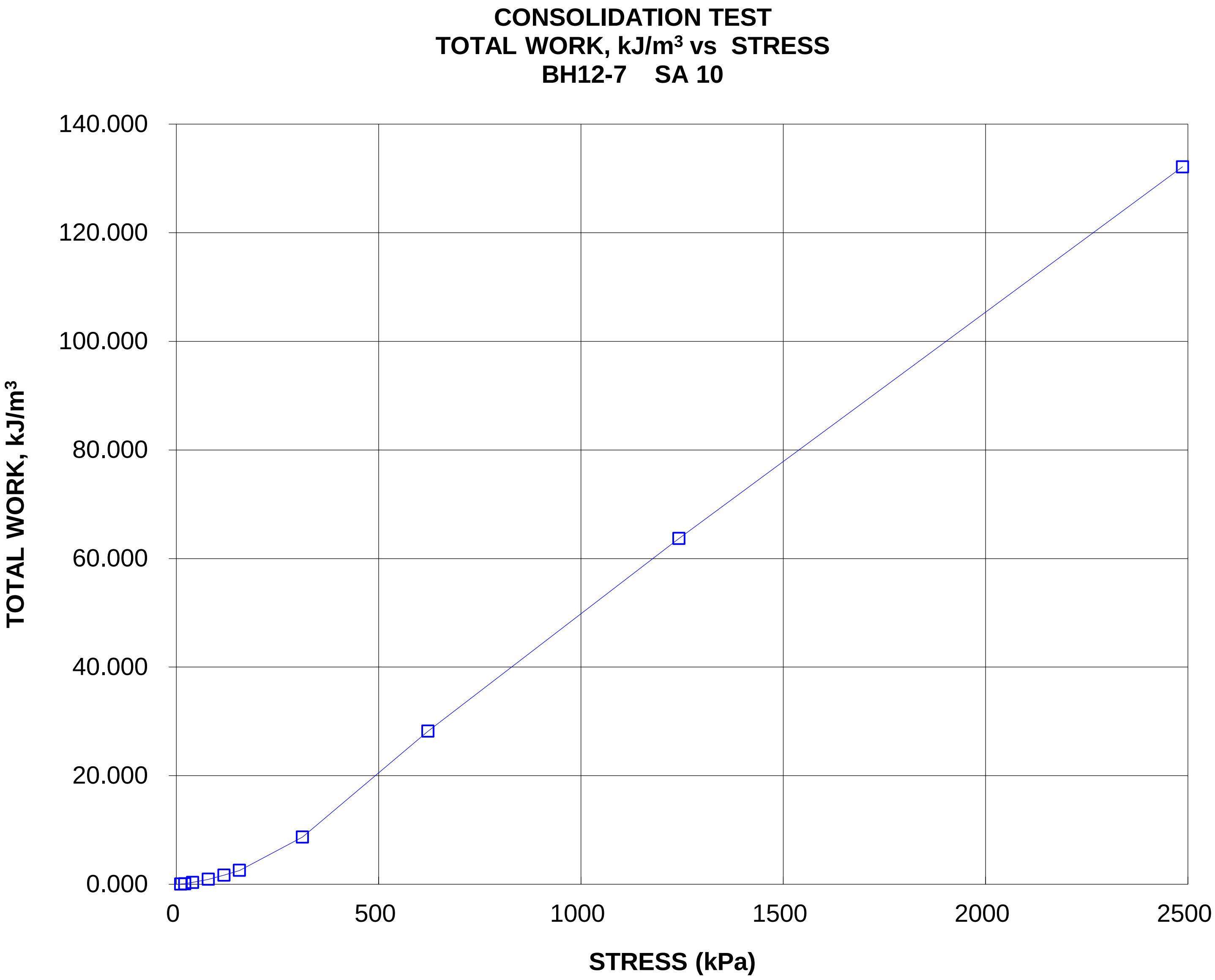


CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE B7
Sheet 4 of 4

CONSOLIDATION TEST SUMMARY

FIGURE B8
Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-0018	Sample Number	T1
Borehole Number	SC-5	Sample Depth, m	12.20-12.65

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	2		
Date Started	06/26/2012		
Date Completed	07/10/2012		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.54	Unit Weight, kN/m^3	20.11
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	16.29
Area, cm^2	31.58	Specific Gravity, measured	2.72
Volume, cm^3	80.09	Solids Height, cm	1.548
Water Content, %	23.49	Volume of Solids, cm^3	48.90
Wet Mass, g	164.26	Volume of Voids, cm^3	31.18
Dry Mass, g	133.01	Degree of Saturation, %	100.2

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.536	0.638	2.536				
5.95	2.513	0.623	2.525	1417	9.54E-04	1.52E-03	1.42E-07
10.66	2.501	0.615	2.507	1009	1.32E-03	9.80E-04	1.27E-07
20.63	2.487	0.606	2.494	1058	1.25E-03	5.70E-04	6.96E-08
39.97	2.466	0.592	2.476	540	2.41E-03	4.30E-04	1.02E-07
78.79	2.439	0.575	2.452	614	2.08E-03	2.77E-04	5.64E-08
156.24	2.404	0.552	2.421	457	2.72E-03	1.78E-04	4.74E-08
312.03	2.352	0.519	2.378	520	2.31E-03	1.31E-04	2.96E-08
622.07	2.276	0.470	2.314	427	2.66E-03	9.64E-05	2.51E-08
1242.57	2.209	0.427	2.243	240	4.44E-03	4.25E-05	1.85E-08
2482.49	2.150	0.388	2.179	265	3.80E-03	1.90E-05	7.07E-09
1242.57	2.150	0.389	2.150				
312.03	2.170	0.401	2.160				
78.79	2.191	0.415	2.180				
20.63	2.220	0.434	2.205				
5.95	2.235	0.443	2.228				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

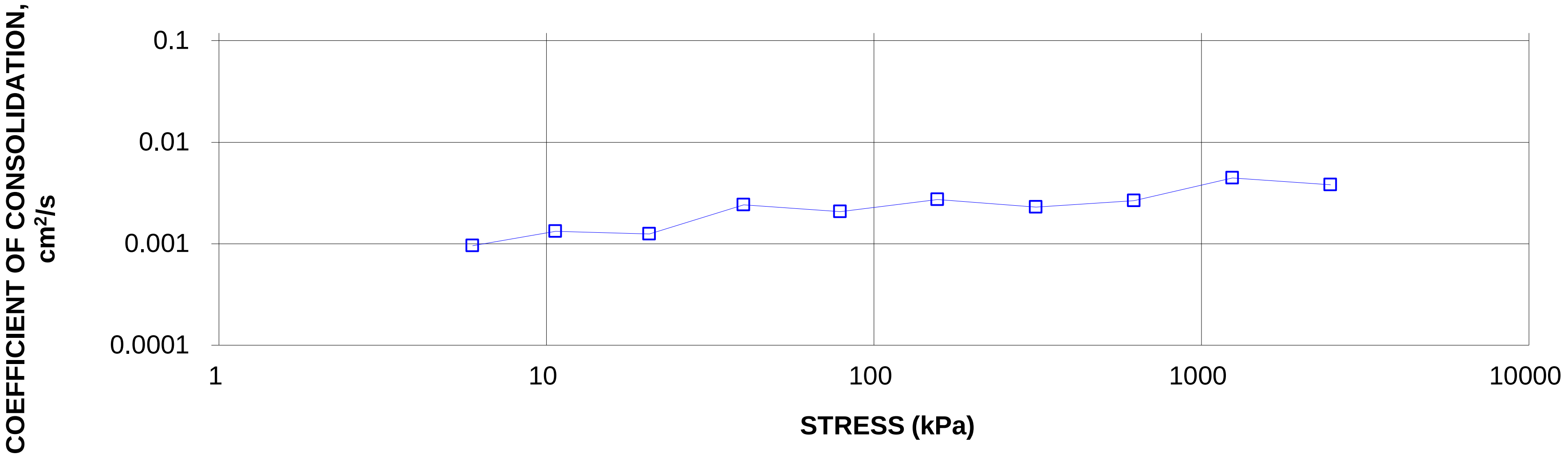
Sample Height, cm	2.24	Unit Weight, kN/m^3	22.06
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	18.48
Area, cm^2	31.58	Specific Gravity, measured	2.72
Volume, cm^3	70.59	Solids Height, cm	1.548
Water Content, %	19.39	Volume of Solids, cm ^{3}	48.90
Wet Mass, g	158.80	Volume of Voids, cm ^{3}	21.69
Dry Mass, g	133.01		

Prepared By: LH **Golder Associates** Checked By: LCC

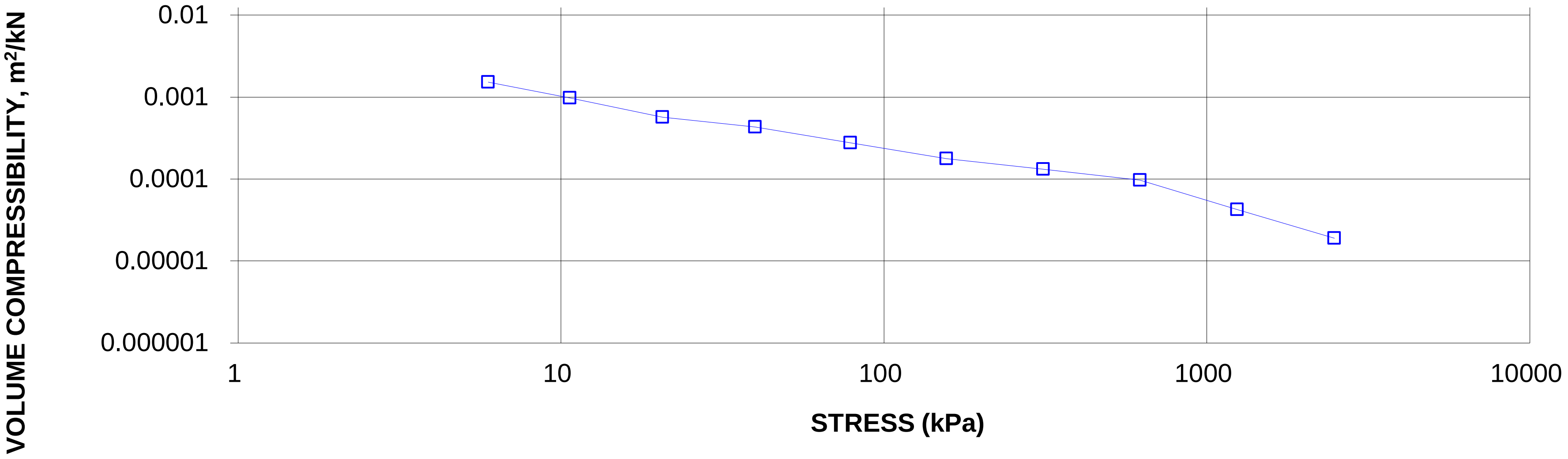
CONSOLIDATION TEST SUMMARY

FIGURE B8
Sheet 2 of 4

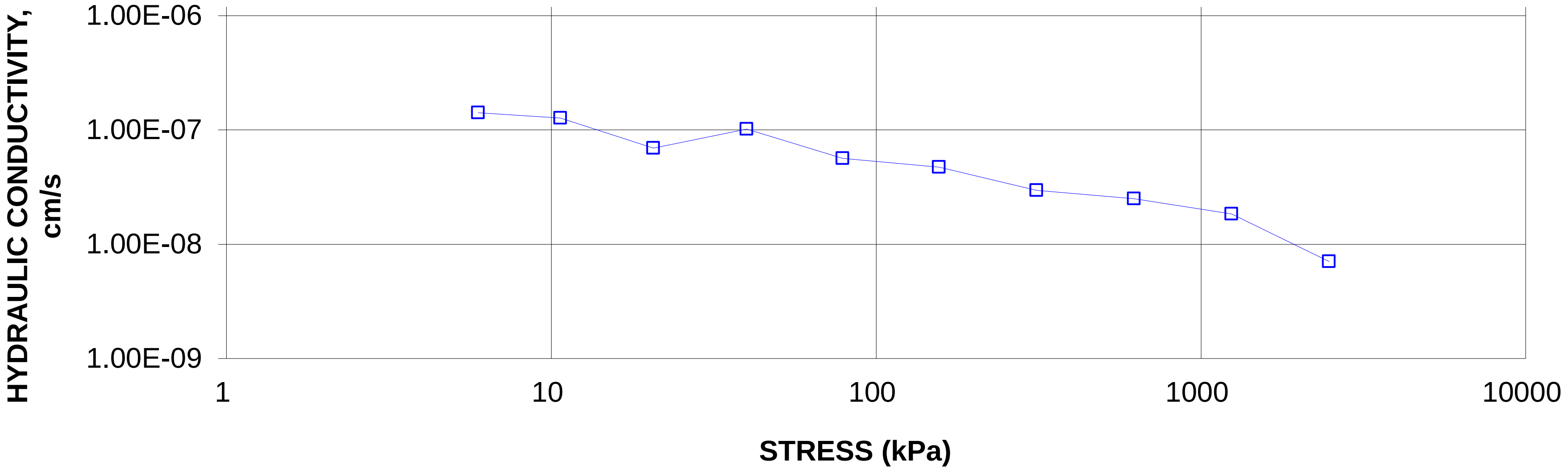
CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
BH SC-5 SA T1



CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
BH SC-5 SA T1



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH SC-5 SA T1



Project No. 09-1111-0018
Prepared By: LH

Golder Associates

Checked By: LCC

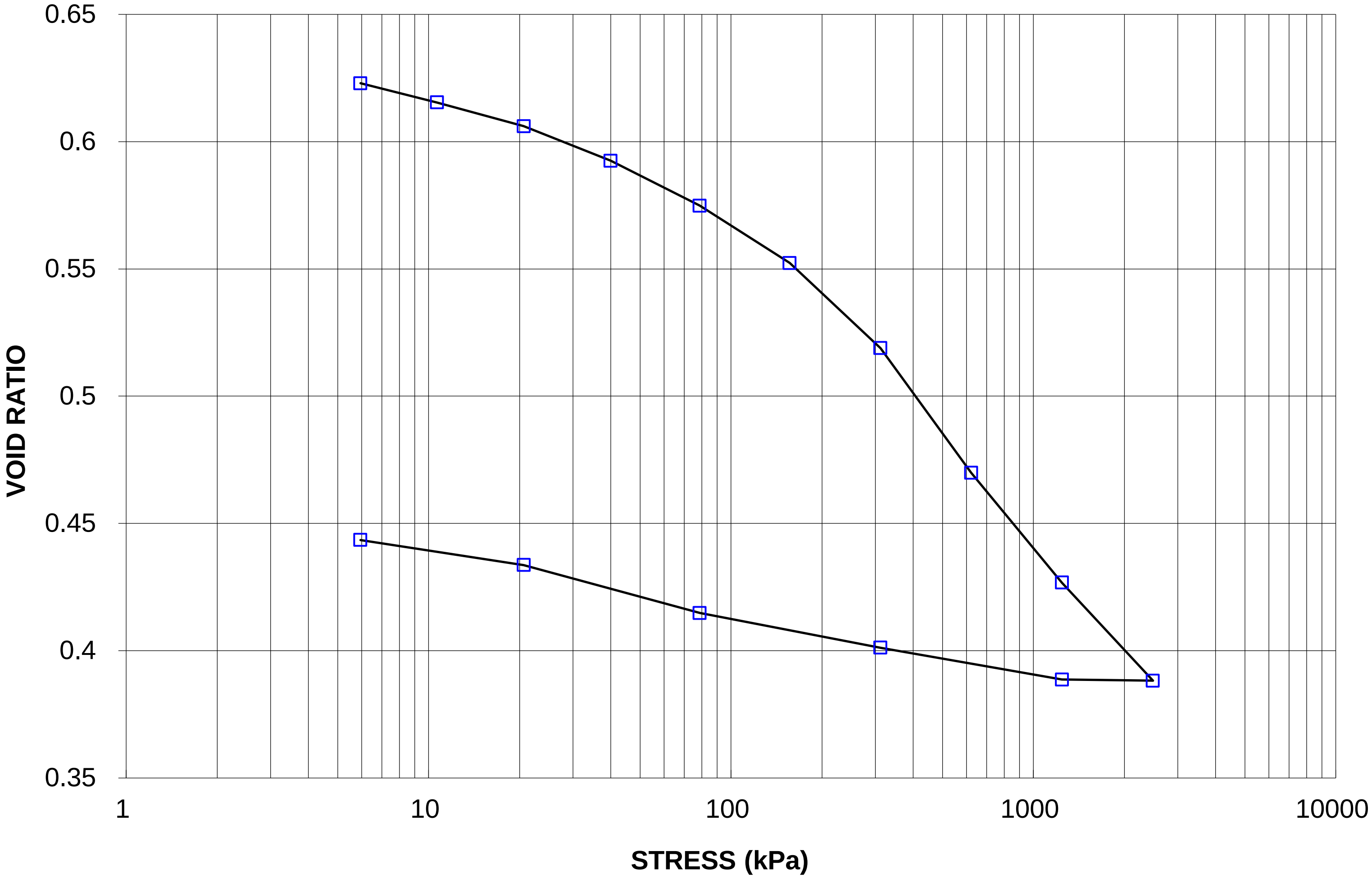
Project No.09-1111-0018

Prepared By: LH

Golder Associates

Checked By: LCC

CONSOLIDATION TEST
VOID RATIO vs STRESS
BH SC-5 SA T1



CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE B8
Sheet 3 of 4

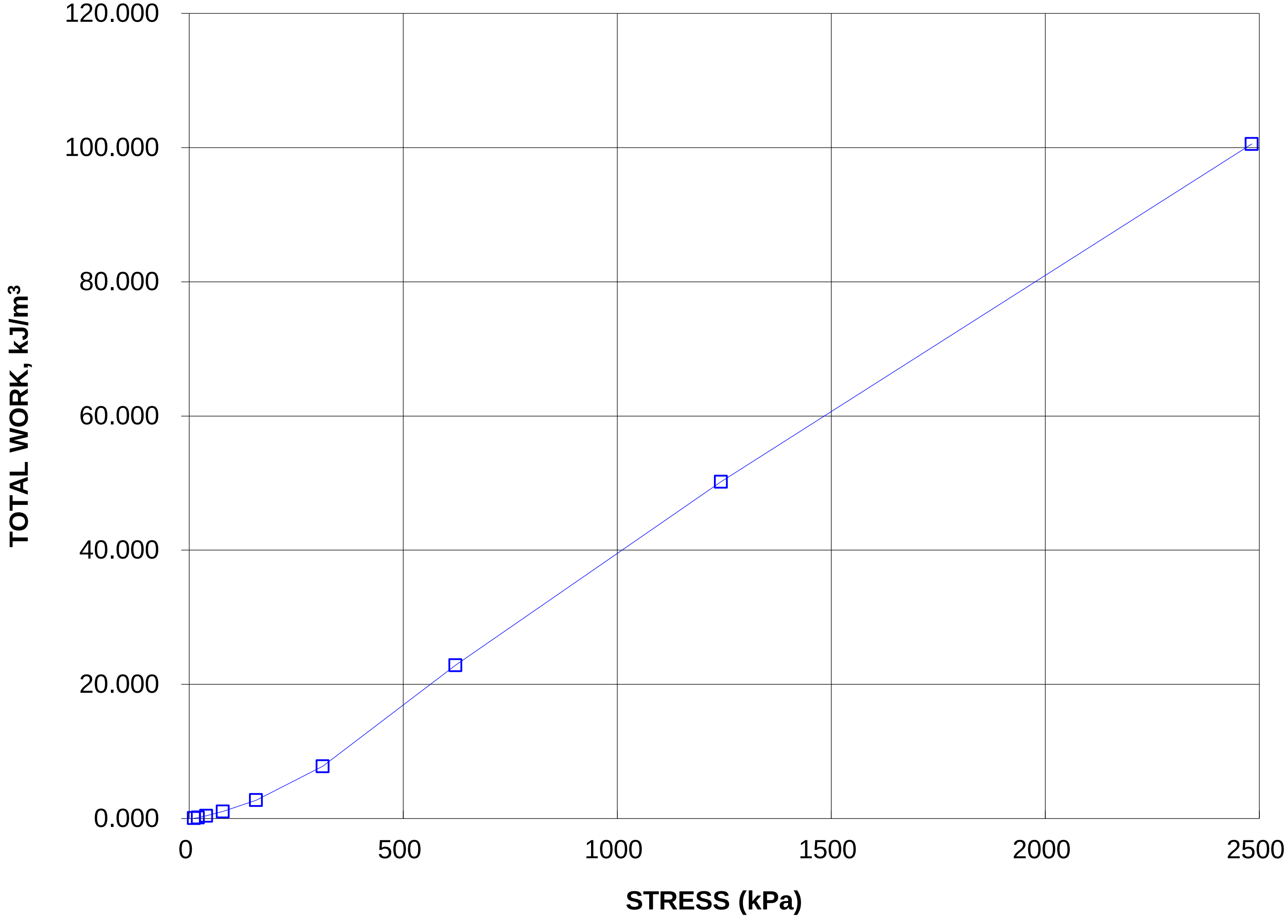
Project No.09-1111-0018

Prepared By: LH

Golder Associates

Checked By: LCC

CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs STRESS
BH SC-5 SA T1



CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE B8
Sheet 4 of 4

CONSOLIDATION TEST SUMMARY

FIGURE B9
Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-0018	Sample Number	11
Borehole Number	SC-7	Sample Depth, m	10.67-11.28

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	9		
Date Started	06/20/2012		
Date Completed	07/05/2012		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.90	Unit Weight, kN/m^3	20.59
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	16.64
Area, cm^2	31.43	Specific Gravity, measured	2.76
Volume, cm^3	59.65	Solids Height, cm	1.167
Water Content, %	23.75	Volume of Solids, cm^3	36.67
Wet Mass, g	125.26	Volume of Voids, cm^3	22.98
Dry Mass, g	101.22	Degree of Saturation, %	104.6

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.898	0.627	1.898				
6.55	1.863	0.596	1.880	1848	4.06E-04	2.85E-03	1.13E-07
11.23	1.851	0.586	1.857	4133	1.77E-04	1.33E-03	2.30E-08
21.21	1.835	0.573	1.843	1370	5.26E-04	8.39E-04	4.32E-08
40.58	1.808	0.550	1.822	470	1.50E-03	7.26E-04	1.07E-07
79.64	1.783	0.528	1.796	622	1.10E-03	3.39E-04	3.65E-08
160.90	1.750	0.500	1.766	454	1.46E-03	2.16E-04	3.08E-08
313.19	1.706	0.462	1.728	406	1.56E-03	1.52E-04	2.32E-08
624.68	1.662	0.425	1.684	228	2.64E-03	7.41E-05	1.91E-08
1247.80	1.616	0.385	1.639	265	2.15E-03	3.91E-05	8.25E-09
2494.02	1.570	0.345	1.593	217	2.48E-03	1.95E-05	4.73E-09
1247.80	1.574	0.349	1.572				
313.19	1.592	0.365	1.583				
79.64	1.616	0.385	1.604				
21.21	1.631	0.398	1.624				
6.55	1.646	0.411	1.639				

Note:
k calculated using cv based on t_{90} values.

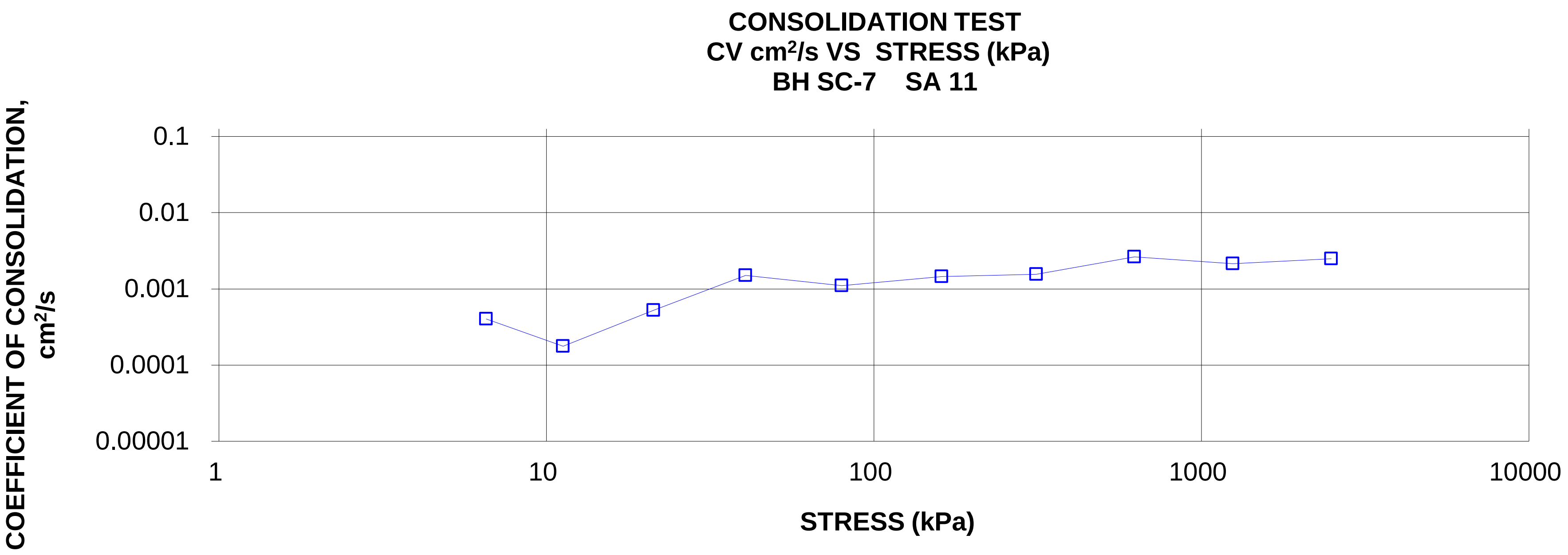
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

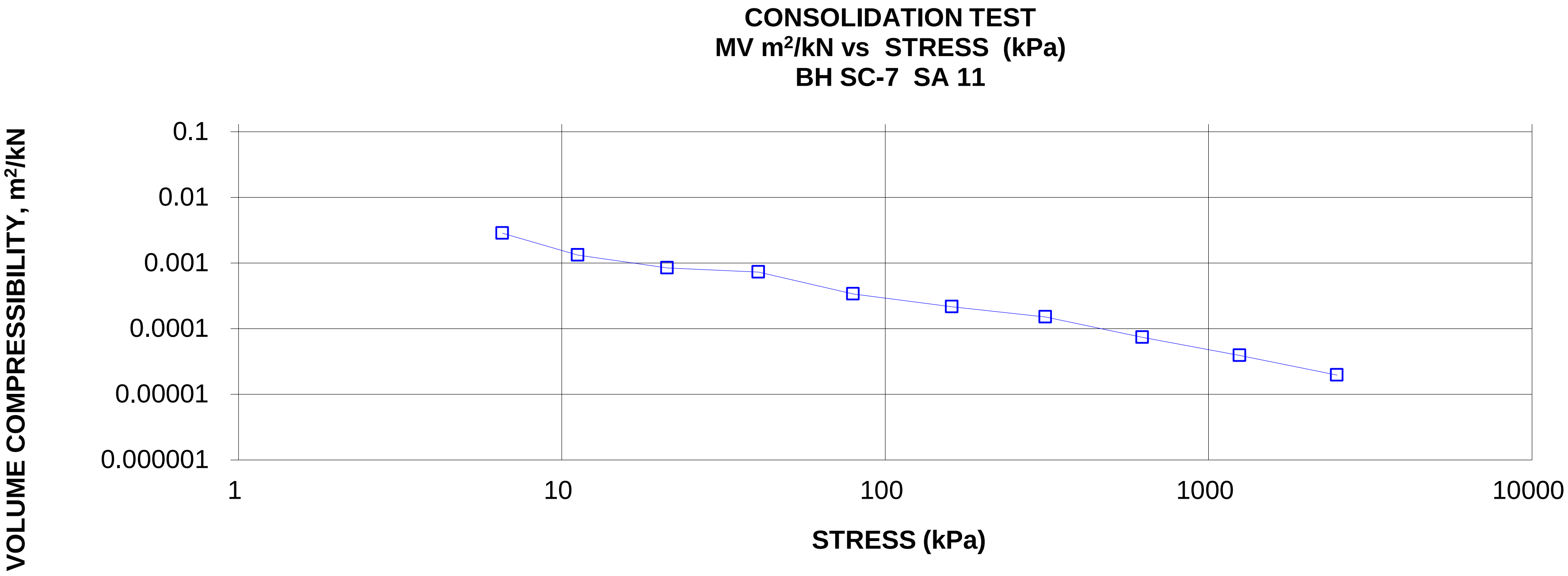
Sample Height, cm	1.65	Unit Weight, kN/m^3	22.67
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	19.19
Area, cm^2	31.43	Specific Gravity, measured	2.76
Volume, cm^3	51.73	Solids Height, cm	1.167
Water Content, %	18.14	Volume of Solids, cm ^{3}	36.67
Wet Mass, g	119.58	Volume of Voids, cm ^{3}	15.06
Dry Mass, g	101.22		

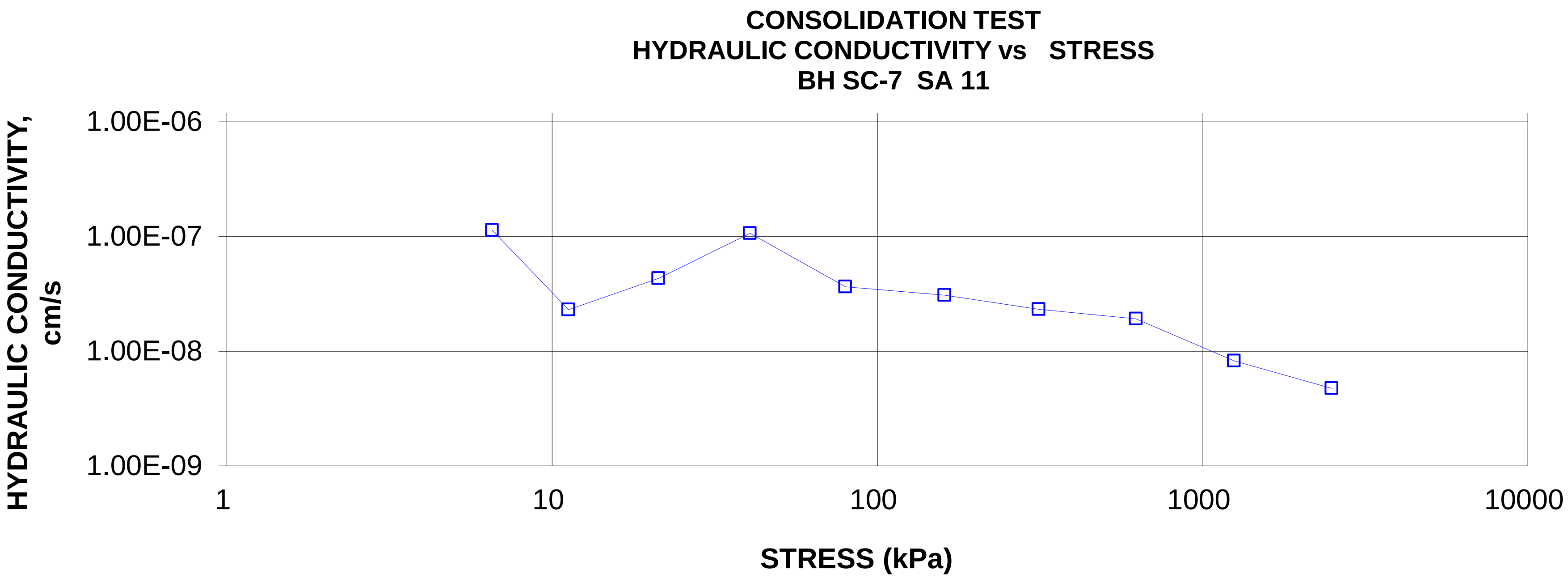
Prepared By: LH **Golder Associates** Checked By: LCC

CONSOLIDATION TEST SUMMARY

FIGURE B9
Sheet 2 of 4







Project No. 09-1111-0018
Prepared By: LH

Golder Associates

Checked By: LCC

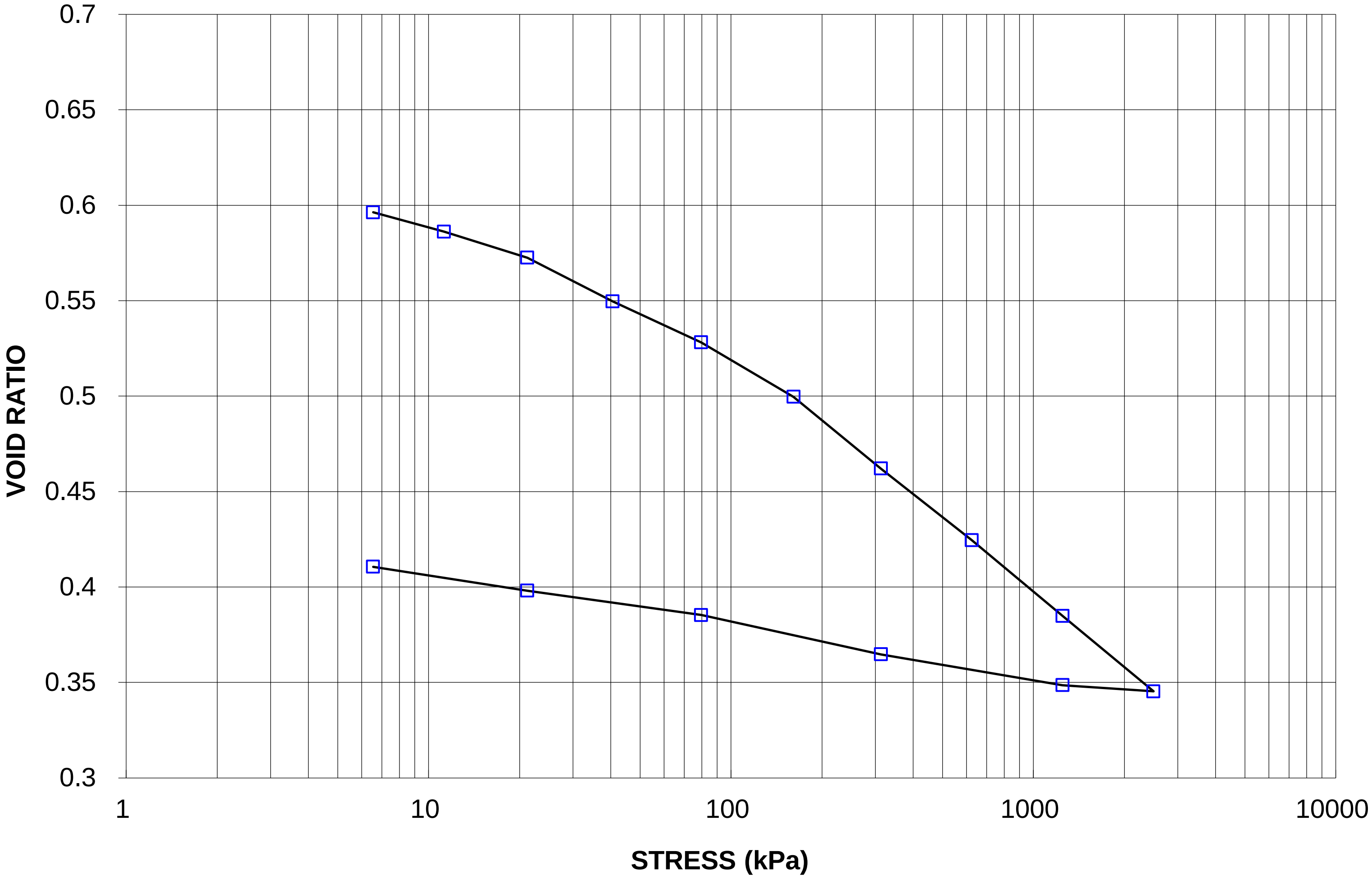
Project No.09-1111-0018

Prepared By: LH

Golder Associates

Checked By: LCC

CONSOLIDATION TEST
VOID RATIO vs STRESS
BH SC-7 SA 11



CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE B9
Sheet 3 of 4

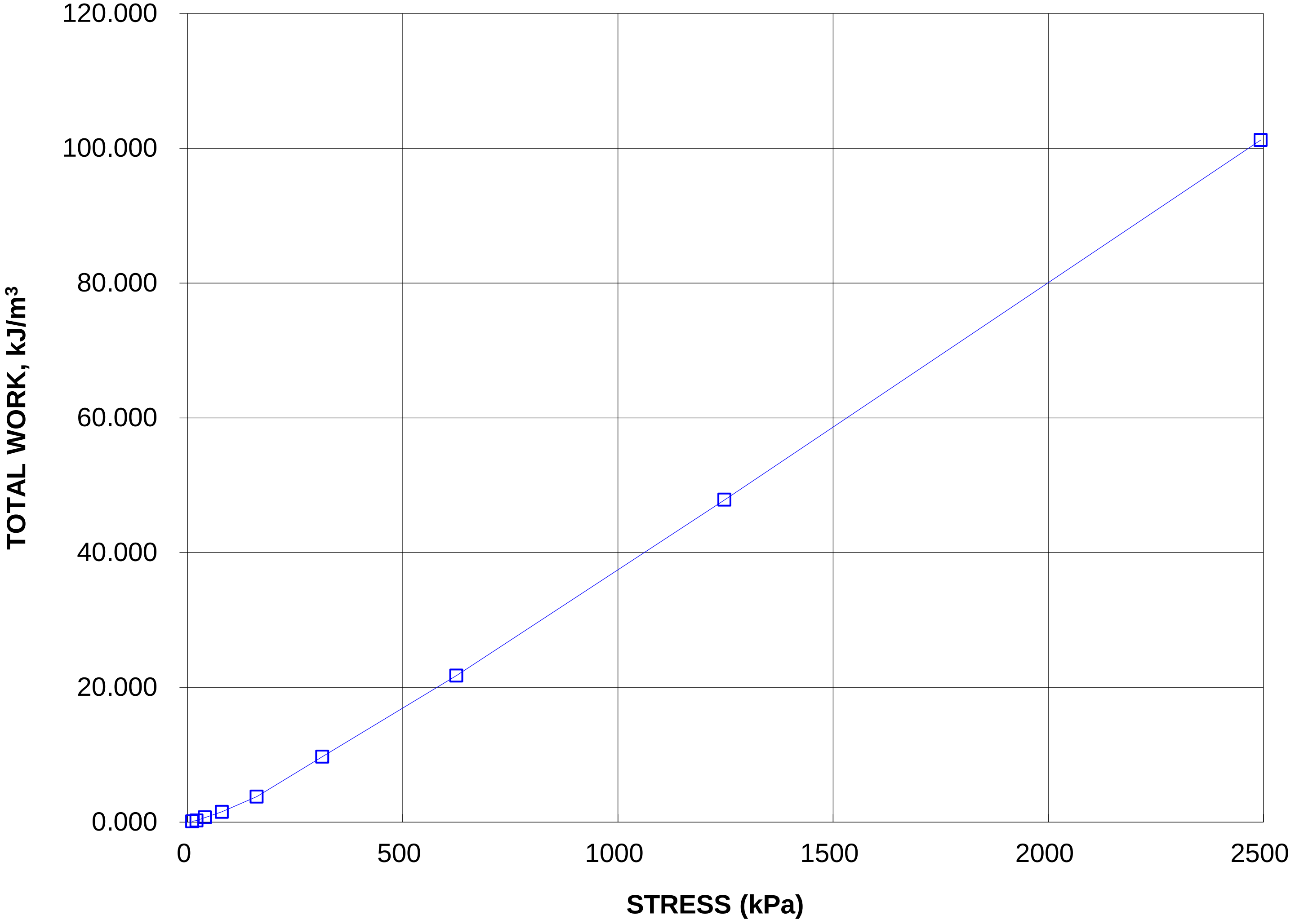
Project No.09-1111-0018

Prepared By: LH

Golder Associates

Checked By: LCC

CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs STRESS
BH SC-7 SA 11



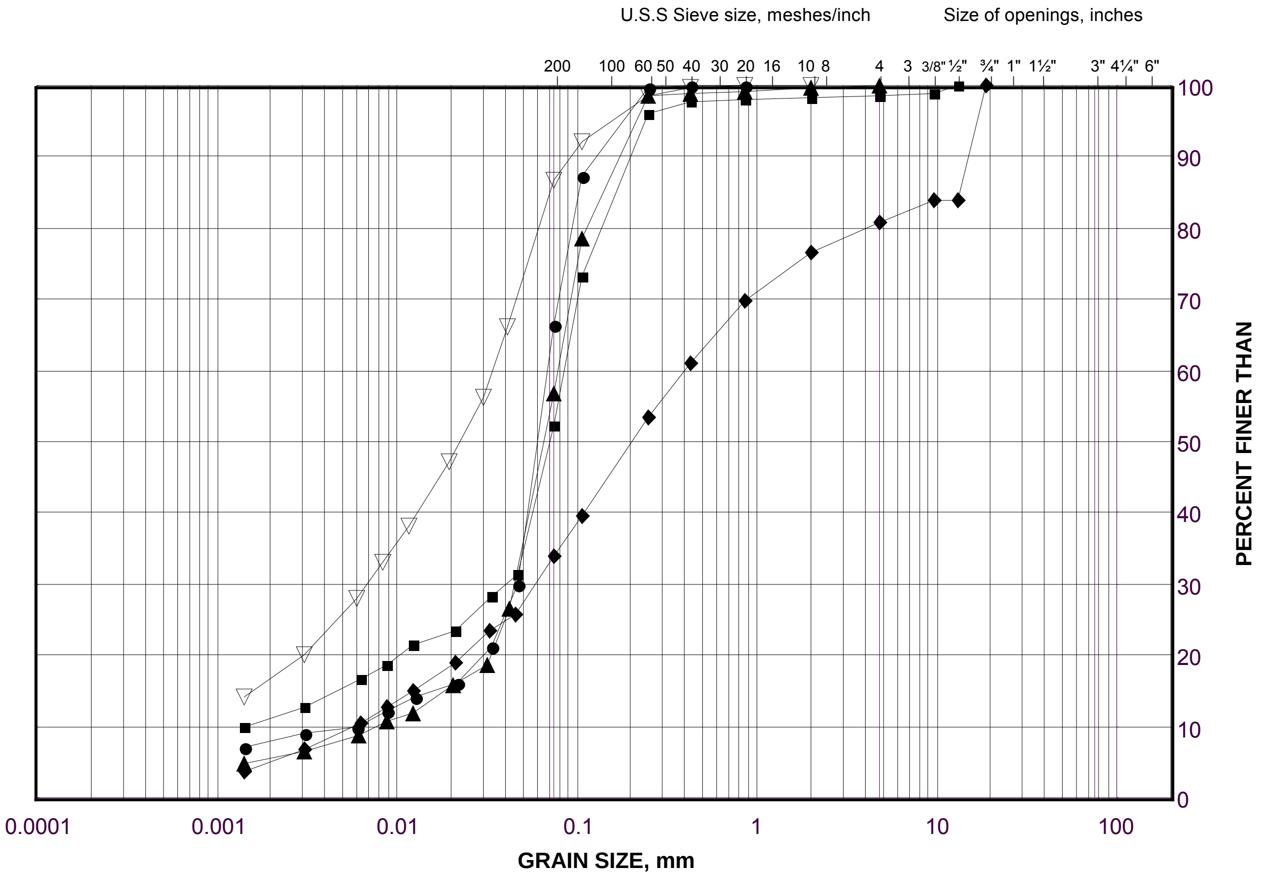
CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE B9
Sheet 4 of 4

GRAIN SIZE DISTRIBUTION

Silt to Sand and Silt (Interlayer)

FIGURE B10



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-9	5	215.4
■	12-6	7	214.9
◆	BO-9	7A	214.8
▲	12-5	8	214.1
▽	12-4	8	213.1

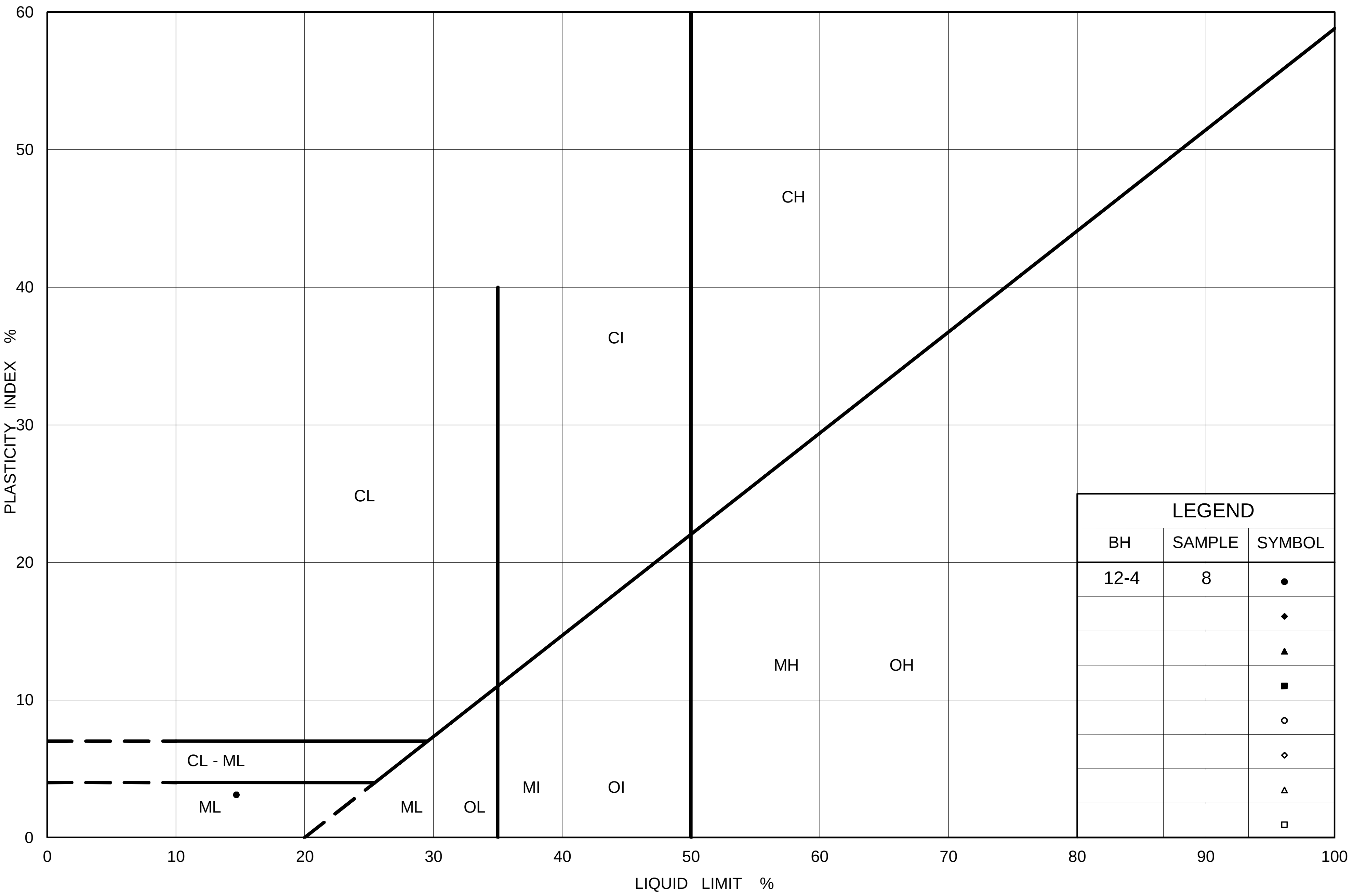
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 11-Jul-13

Oct 75, FF-S-21



Ministry of Transportation

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PLASTICITY CHART
Silt Interlayer

Figure No. B11

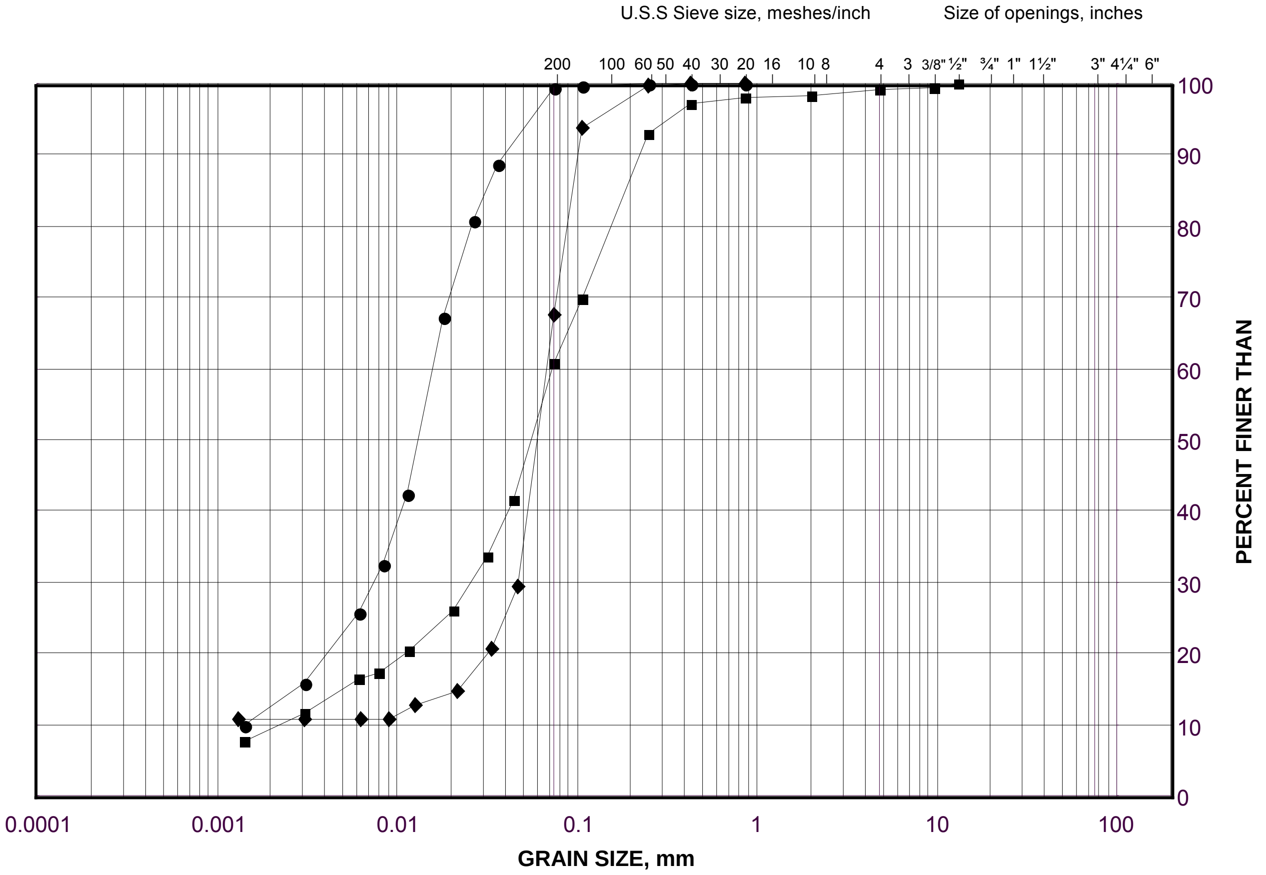
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Silt to Sand and Silt

FIGURE B12A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	BO-9	13	205.5
■	SC-7	14	205.3
◆	BO-9	15	202.4

Project Number: 09-1111-0018

Checked By: LCC

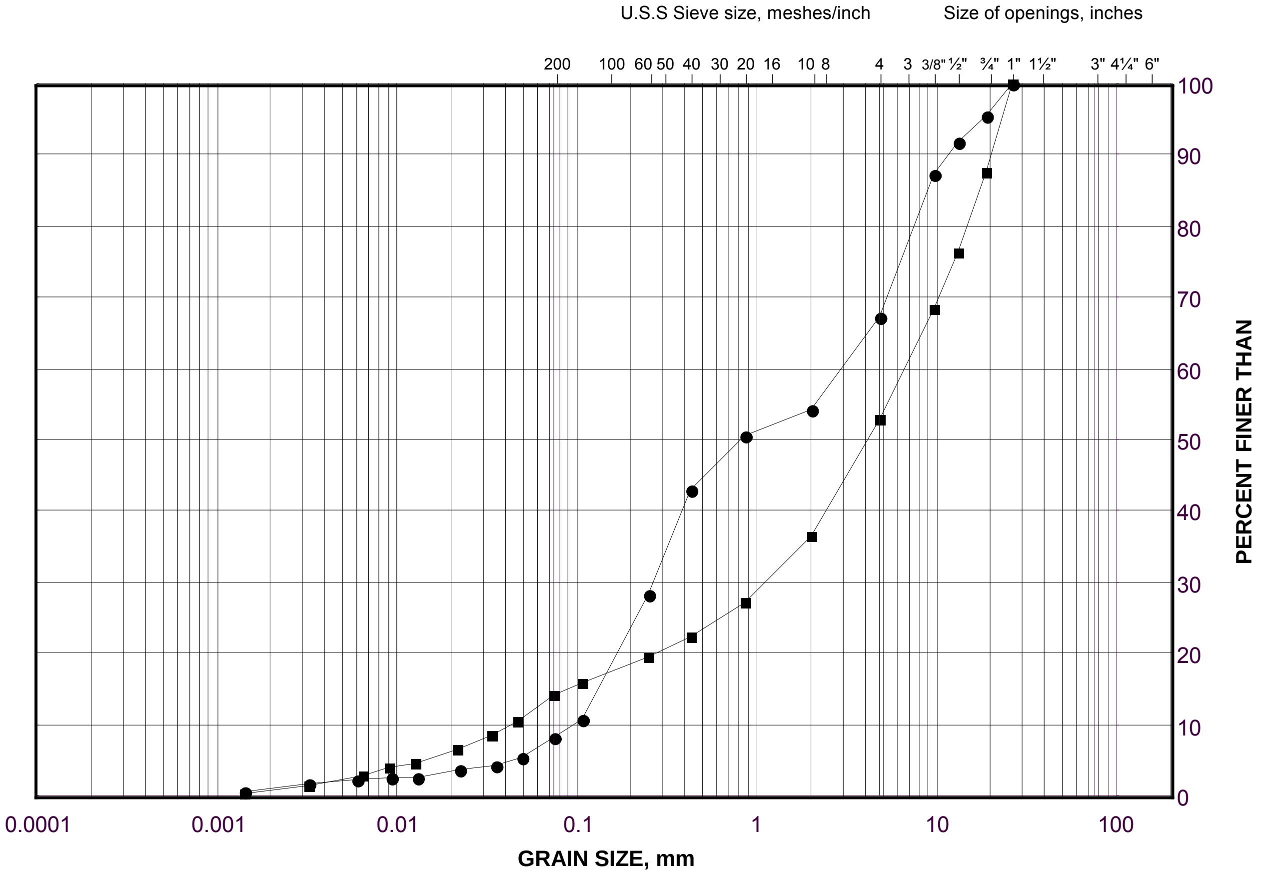
Golder Associates

Date: 08-Feb-13

GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE B12B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-7	17	200.7
■	SC-7	27	180.8

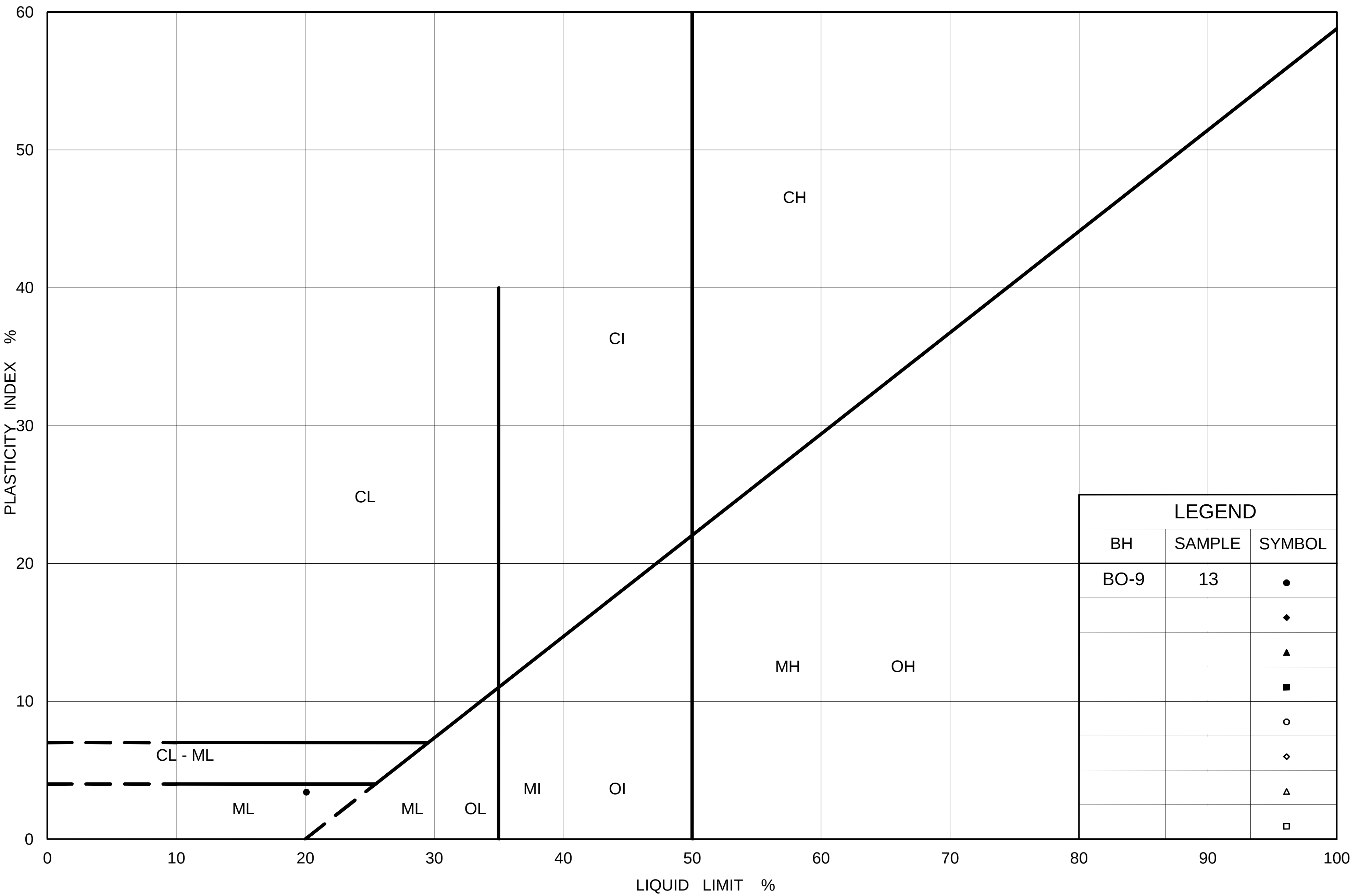
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 08-Feb-13

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
BO-9	13	●
		◆
		▲
		■
		○
		◇
		△
		□

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Ontario

PLASTICITY CHART
Silt

Figure No. B13

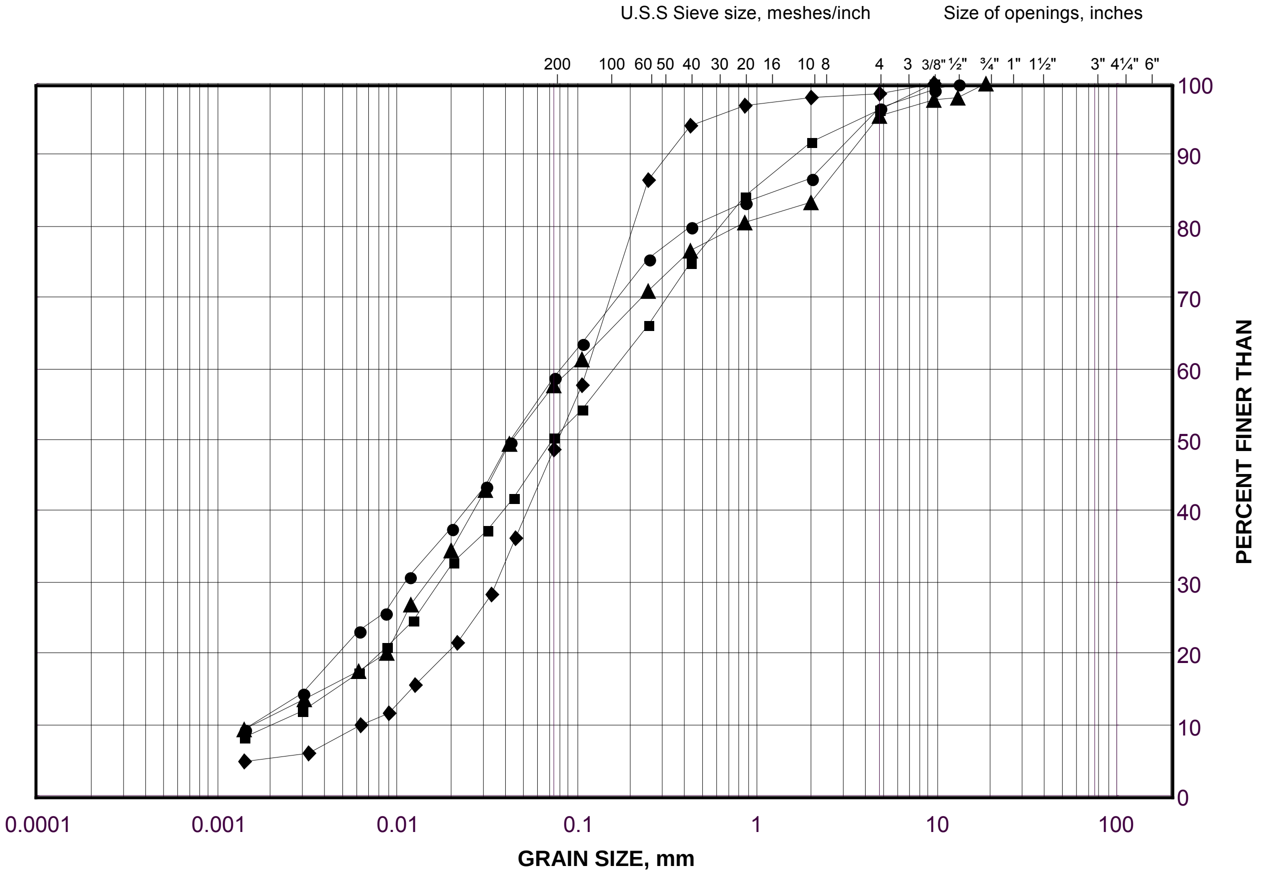
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Sand and Silt (Till)

FIGURE B14



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-7	17	200.4
■	12-4	17	199.7
◆	12-9	18	196.3
▲	12-6	20	196.6

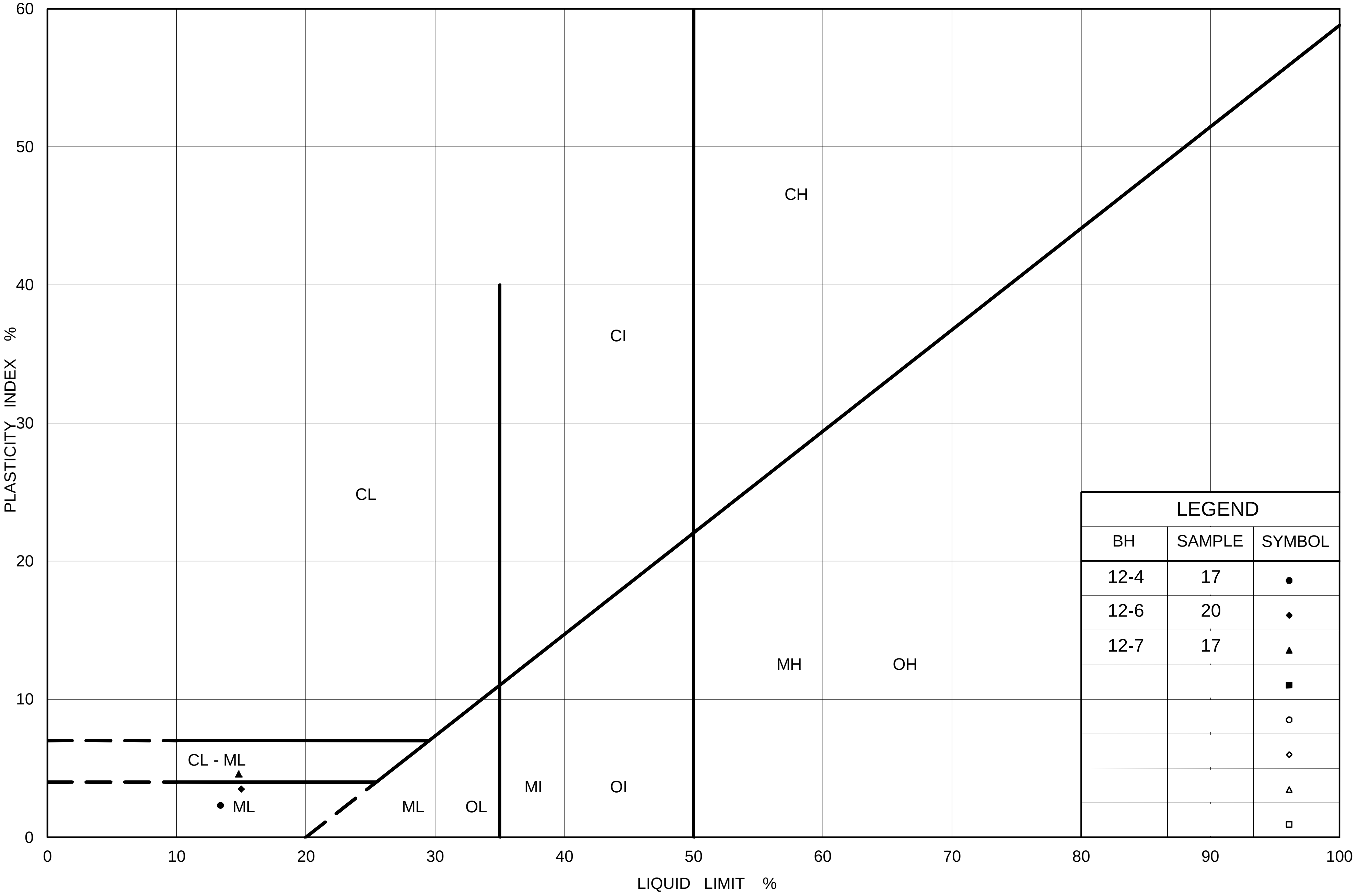
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 08-Feb-13

Oct 75, FF-S-21



BH	SAMPLE	SYMBOL
12-4	17	●
12-6	20	◆
12-7	17	▲
		■
		○
		◇
		△
		□

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Ontario

PLASTICITY CHART
Sand and Silt (Till)

Figure No. B15

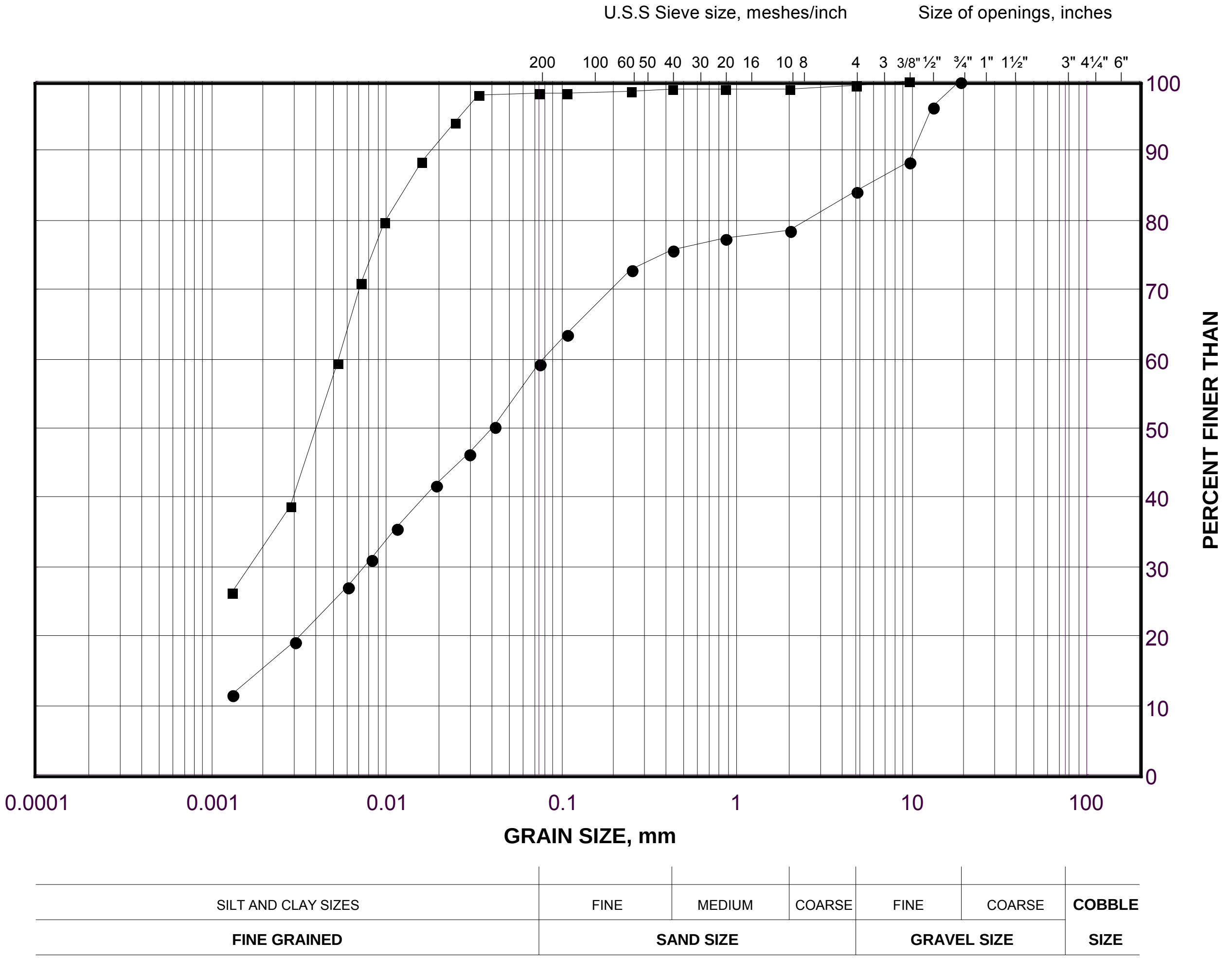
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Clayey Silt Interlayers

FIGURE B16



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	BO-9	19A	196.4
■	SC-7	25	186.9

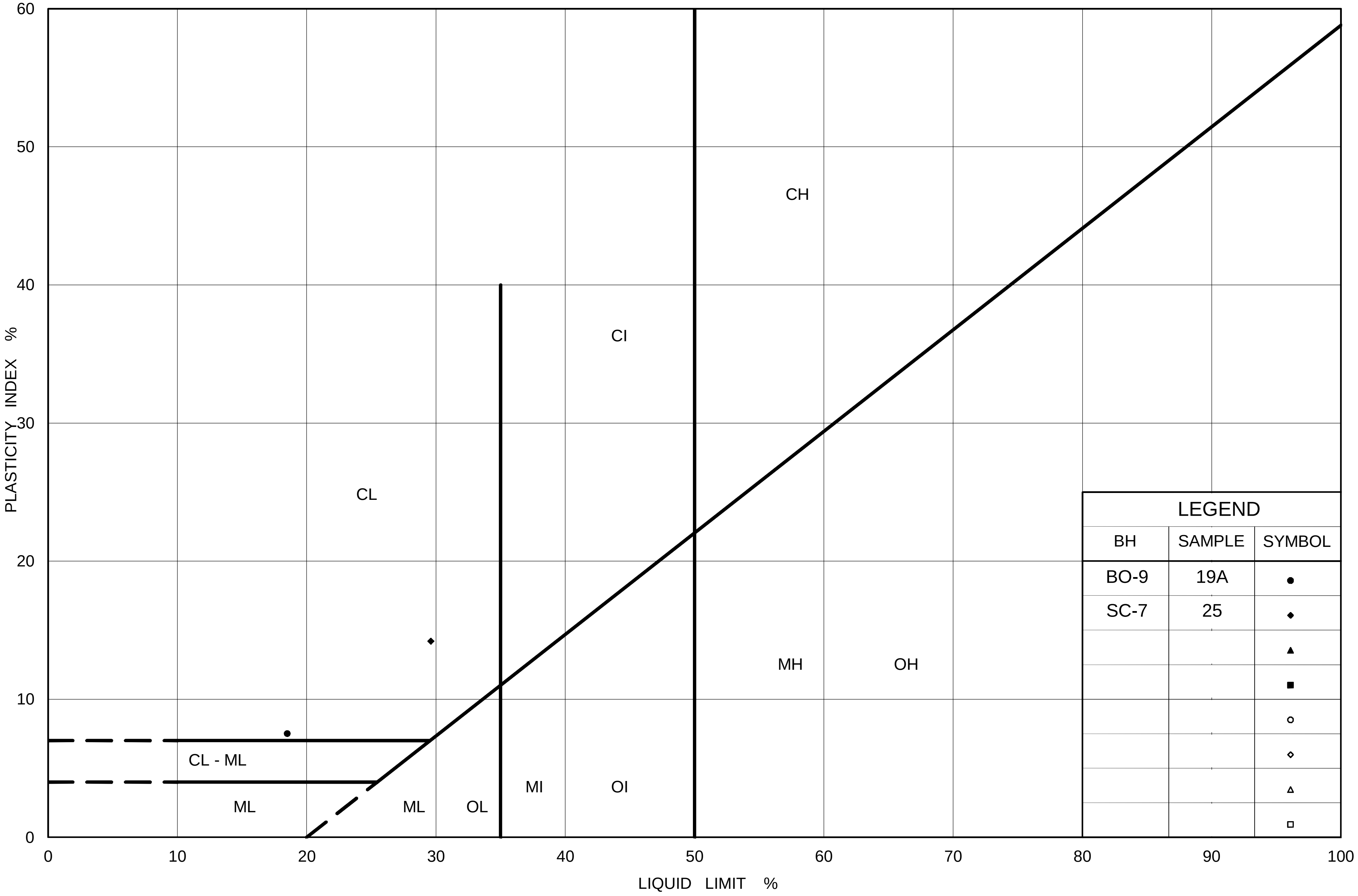
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 25-Jan-13

Oct 75, FF-S-21



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PLASTICITY CHART
Clayey Silt Interlayer

Figure No. B17

Project No. 09-1111-0018

Checked By: LCC

APPENDIX C

Borehole Records and Laboratory Test Results – South Canal Bank Road - Station 9+860 to Station 10+100

RECORD OF BOREHOLE No 12-1

SHEET 1 OF 1

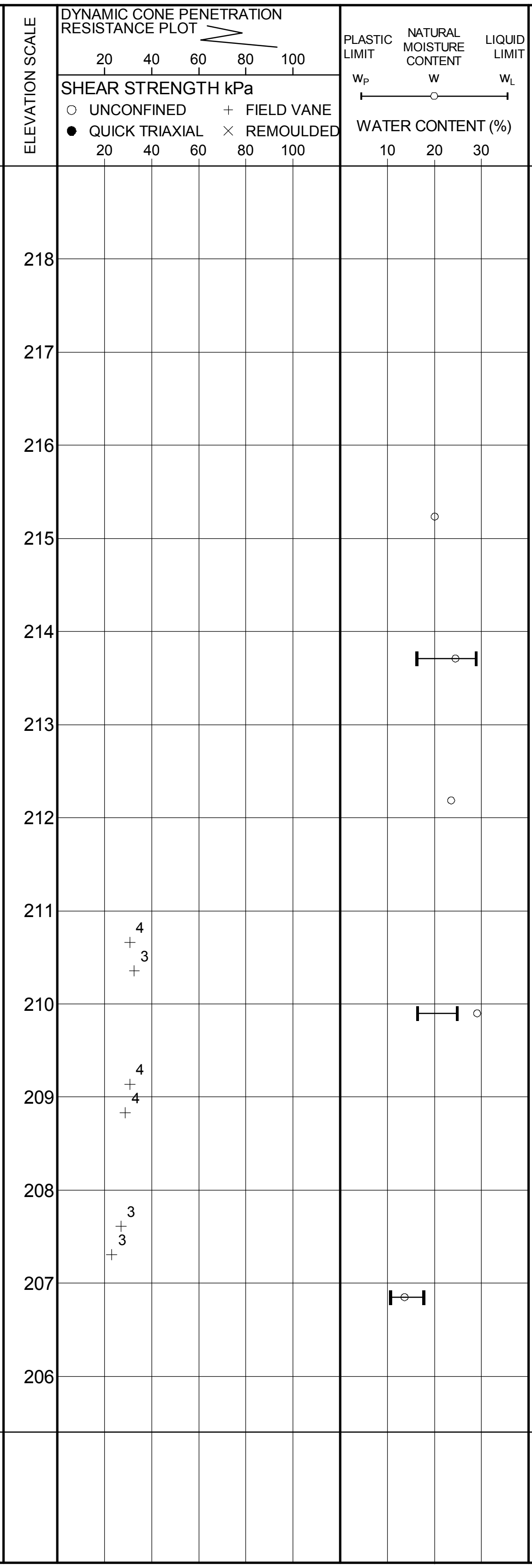
METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4877101.4 ;E 297123.6
BOREHOLE TYPE D-25 Barge Mount, 89 mm O.D. Tricone Wash Bore, N Casing
DATE June 25, 2012

ORIGINATED BY TWB
COMPILED BY CC
CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
219.0	TOP OF WATER							
0.0	WATER							
216.3 2.7	CLAYEY SILT, some sand, trace gravel, containing organics and rootlets Very soft to soft Grey Moist to wet	1	SS	1				
215.5 3.5	CLAYEY SILT, trace to some sand Soft to very stiff Grey Moist	2	SS	16				
		3	SS	12				
		4	SS	14				
		5	SS	13				
		6	SS	16				
	firm to soft below 7.2 m depth	7	SS	5				
		8	SS	4				
		9	SS	2				
207.1 11.9	CLAYEY SILT with sand, trace gravel (TILL) Stiff to hard Grey Moist	10	SS	9	4	24	51	21
		11	SS	80/0.10				
205.4 13.6	END OF BOREHOLE Note : The water level in the N casing borehole was not recorded upon completion of drilling							



GROUND WATER CONDITIONS | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-2

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4877138.4 ;E 297168.4

BOREHOLE TYPE D-25 Barge Mount, 89 mm O.D. Tricone Wash Bore, N Casing

DATE June 26, 2012

ORIGINATED BY TWB

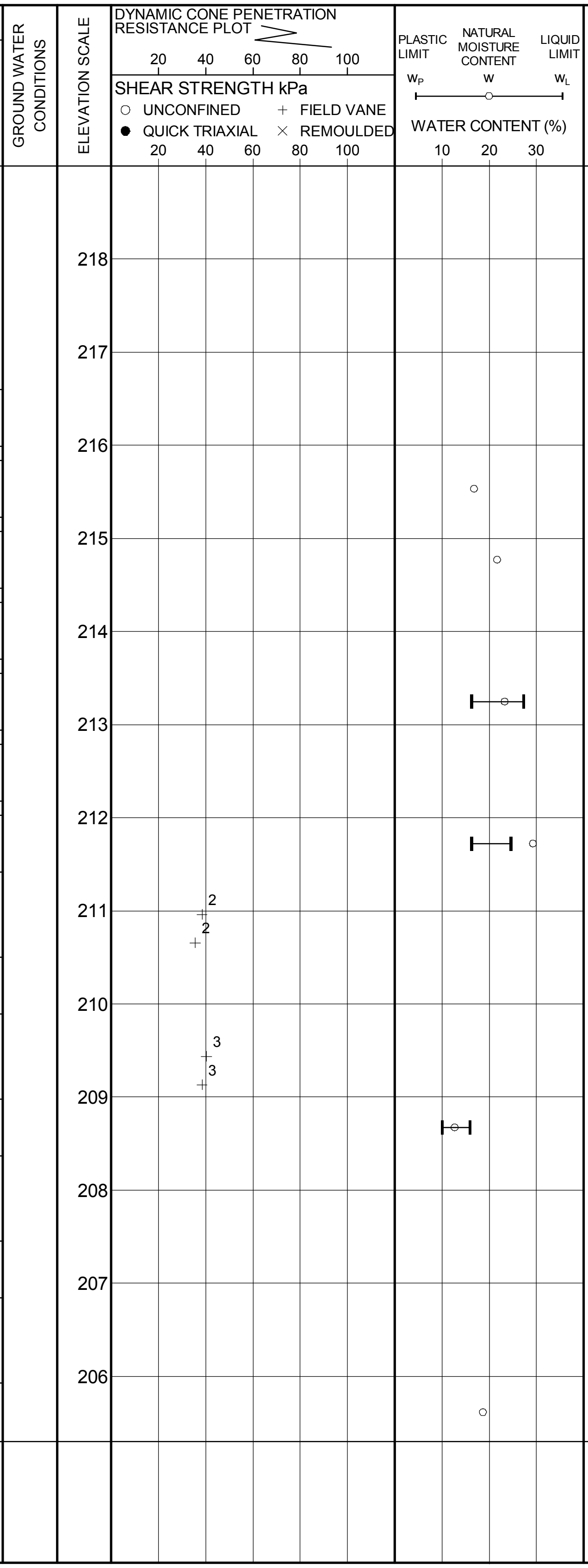
COMPILED BY CC

CHECKED BY SMM

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
219.0	TOP OF WATER							
0.0	WATER							
216.6 2.4	CLAYEY SILT, trace to some sand, trace gravel, containing organics Very soft Grey Wet	1	SS	0				
215.9 3.1	CLAYEY SILT, trace to some sand Firm to very stiff Grey Moist	2	SS	21				
		3	SS	12				
		4	SS	17				
	firm below 5.4 m depth	5	SS	8				
		6	SS	5				
		7	SS	4				
		8	SS	5				
208.9 10.1	CLAYEY SILT with sand, trace to some gravel (TILL) Firm Grey Moist	9	SS	7	13	32	38	17
207.9 11.1	SAND, trace trace to some silt Loose to dense Grey Wet	10	SS	5				
		11	SS	31	1	87	8	4
205.3 13.7	END OF BOREHOLE Note : The water level in the N casing was coincident with the surface water of the canal.							

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)



$+^3$, $\times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-11

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4877137.4 ;E 297197.1
BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing
DATE July 11 and 12, 2012

ORIGINATED BY OS
COMPILED BY CC
CHECKED BY SMM

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
219.5	GROUND SURFACE
0.0	TOPSOIL
0.2	Clayey silt, some sand, trace gravel, containing rootlets and organics (FILL) Soft Dark brown to grey Moist
218.7 0.8	Clayey silt with sand, trace gravel, containing wood fragments to a depth of 2.3 m (FILL) Firm to stiff Grey Moist to wet
215.8 3.7	CLAYEY SILT, trace sand Firm to stiff Grey Moist
211.5 8.0	Silty SAND to SAND, trace silt, trace gravel Compact to dense Grey Wet
208.8 10.7	END OF BOREHOLE

NOTE:

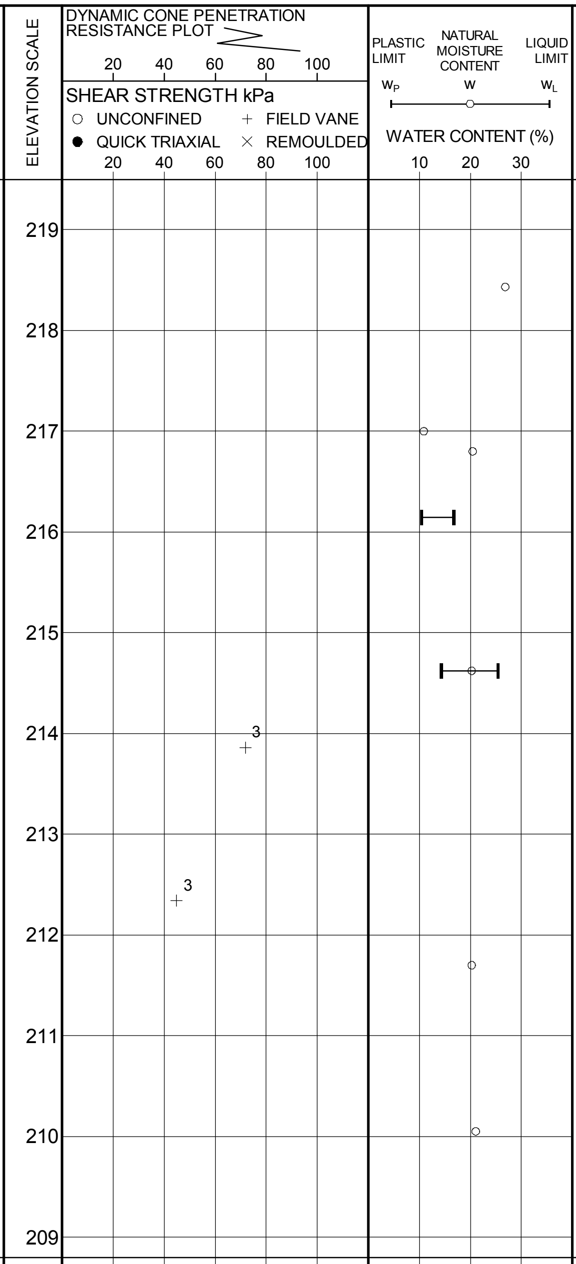
1. Artesian conditions encountered at a depth of 8.0 m (Elev. 211.5 m) during drilling.

2. Water level not measured in borehole upon completion of drilling.

3. Borehole backfilled with a cement having a ratio of 1 water to 2 cement.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	3				
2	SS	10				
3	SS	7				
4A 4B	SS	11	0	29	58	13
5	SS	5	1	32	53	14
6	SS	11				
7	SS	15				
8	SS	11				
9A 9B	SS	11				
10	SS	28				



GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

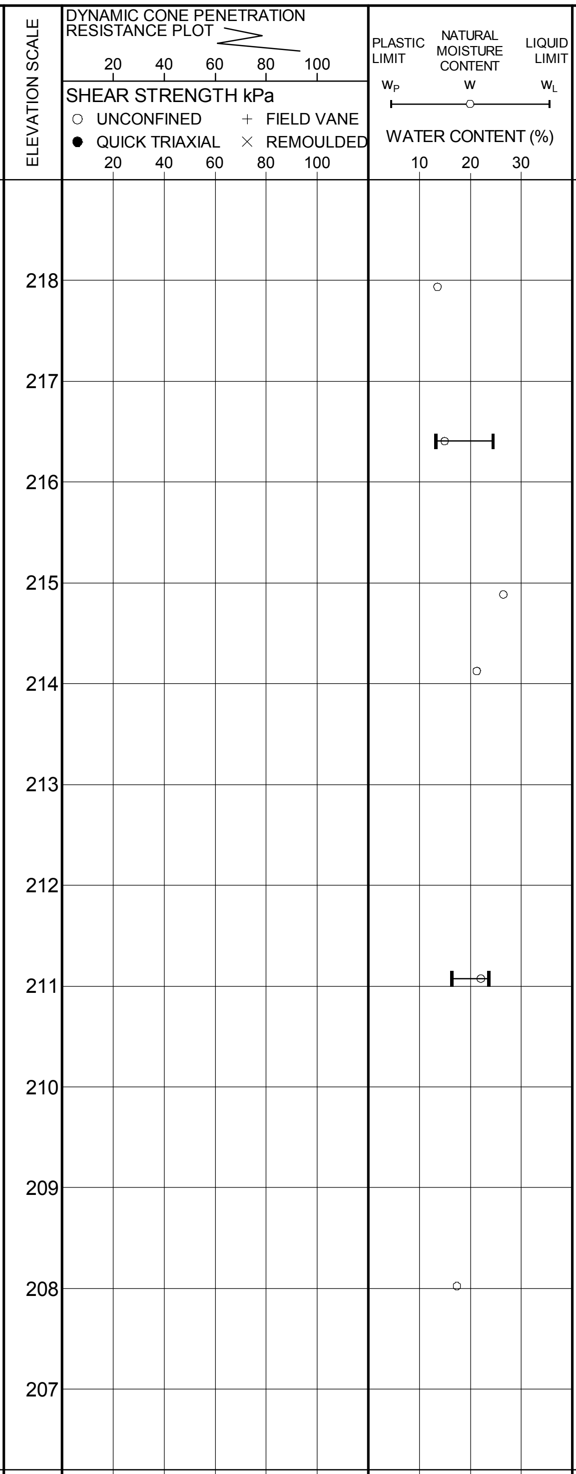
RECORD OF BOREHOLE No 12-12

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
LOCATION N 4877173.1 ;E 297222.1
ORIGINATED BY TWB
DIST Central HWY 400
BOREHOLE TYPE D-50 Track Mount, 210 mm Inside Diameter Hollow Stem Augers
COMPILED BY CC
DATUM Geodetic
DATE May 15, 2012
CHECKED BY SMM

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
219.0	GROUND SURFACE										
0.0	Clayey silt with sand, trace gravel, containing organics, containing layers of silty sand (FILL) Soft to stiff Brown Moist	▨	1	SS	13	▽					
			2	SS	10						
			3	SS	4						
			4	SS	3			15	46	25	14
215.3	containing rootlets and wood fragments below a depth of 3.0 m		5	SS	4						
3.7	CLAYEY SILT with sand, trace gravel, containing organics, rootlets and wood fragments Soft Grey Moist		6	SS	3		OC = 3.8%				
214.4 4.6	CLAYEY SILT, trace sand Firm to stiff Grey Moist		7	SS	6						
			8	SS	13						
209.6			9	SS	9			0	1	75	24
9.4	SILT, trace clay, trace sand Compact to very dense Grey Wet		10A 10B	SS	19						
			11	SS	67			0	2	90	8
206.2			12	SS	63						
12.8	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 0.4 m below ground surface (Elev. 218.6 m) upon completion of drilling.										



+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Foundation Design

RECORD OF BOREHOLE No 12-13

SHEET 1 OF 2

METRIC

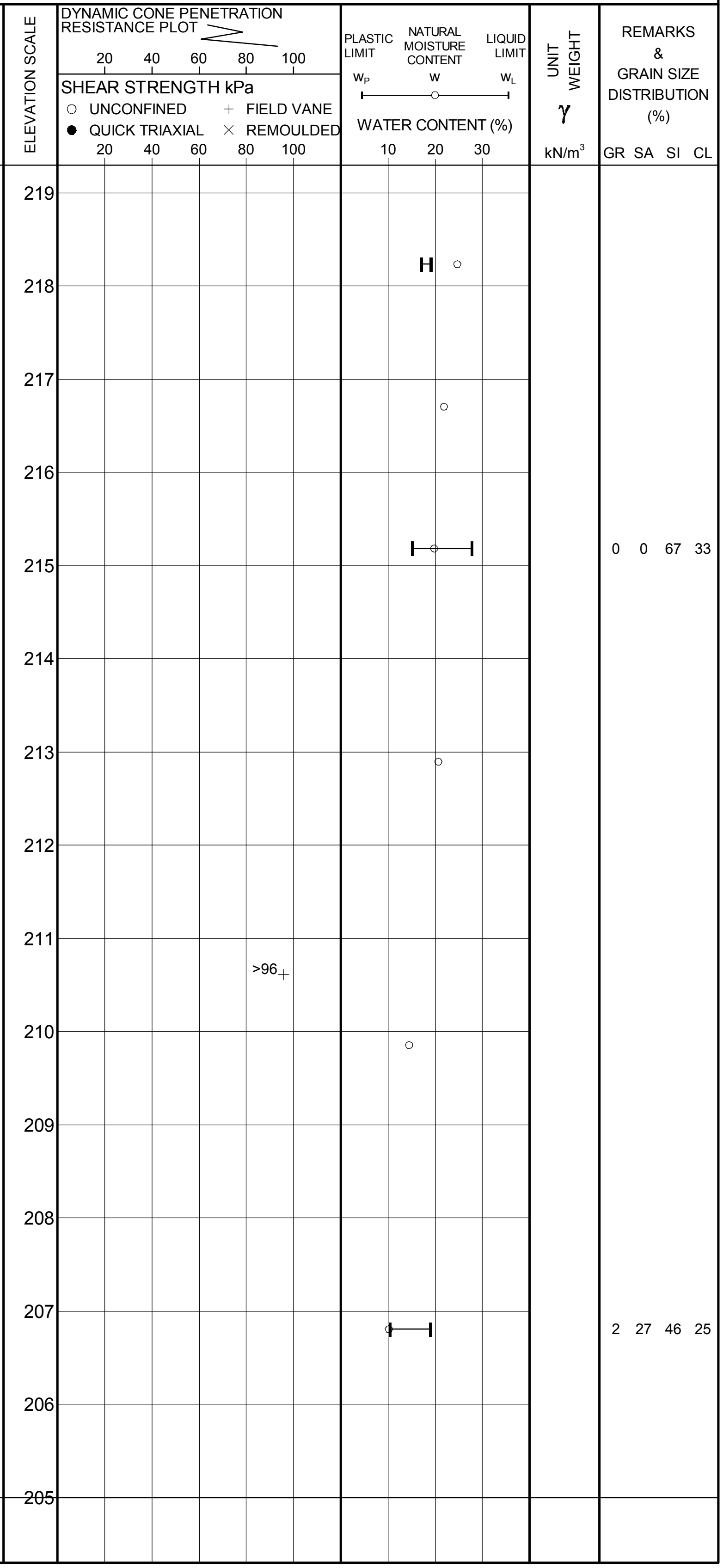
PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4877053.3 ;E 297098.6
BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing
DATE May 10,2012

ORIGINATED BY OS
COMPILED BY CC
CHECKED BY SMM

ELEV DEPTH	SOIL PROFILE – DESCRIPTION
219.3	GROUND SURFACE
0.0	TOPSOIL
218.8 0.6	CLAYEY SILT, trace to some sand, containing organics, rootlets and oxidation staining Soft Dark brown Wet
	PEAT, Soft Brown Moist
217.3 2.0	SILT, some sand, trace clay Compact Brown and grey Moist to wet
	CLAYEY SILT, containing silt seams to a depth of 2.1 m Stiff to hard Grey Moist
210.6 8.7	CLAYEY SILT with sand, trace to some gravel (TILL) Hard Grey Moist
205.0 14.3	END OF BOREHOLE

SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
1	SS	3					
2	SS	14					
3A 3B	SS	13					
4	SS	18					
5	SS	22					
6	SS	21		0	0	67	33
7	SS	18					
8	SS	31	∇				
9	SS	10					
10	SS	71					
11	SS	86					
12	SS	80		2	27	46	25
13	SS	71					



Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-13

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4877053.3 ;E 297098.6

BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing

DATE May 10,2012

ORIGINATED BY OS

COMPILED BY CC

CHECKED BY SMM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION --- *CONTINUED FROM PREVIOUS PAGE* ---	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	NOTE: 1. Water level in open borehole at a depth of 6.6 m below ground surface (Elev. 212.7 m) upon completion of drilling.										

+^{3}, ×^{3}: Numbers refer to Sensitivity

○$^{3\%}$ STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-0018 (URS, YORK REGION)\LOG\0911110018.GPJ GAL-GTA.GDT 01/13/15 SIB

RECORD OF BOREHOLE No 12-14

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4877039.6 ;E 297057.1

BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing

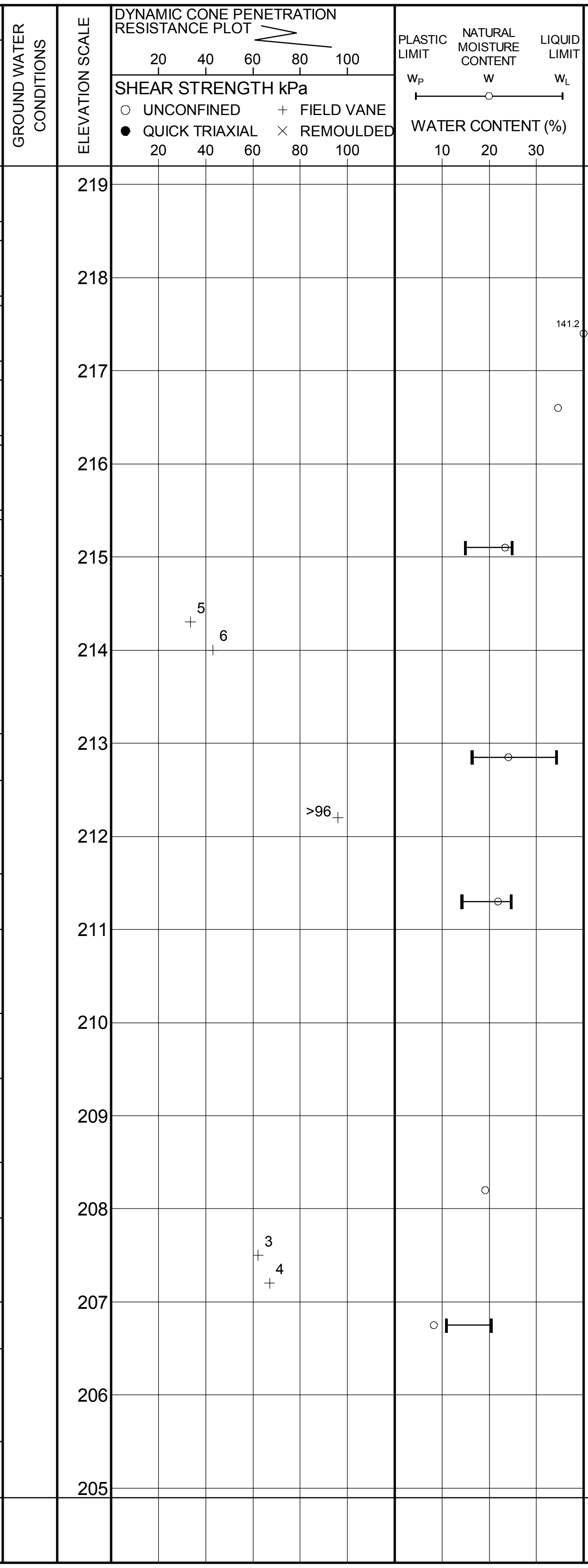
DATE May 9,2012

ORIGINATED BY MS

COMPILED BY CC

CHECKED BY SMM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
219.2	GROUND SURFACE								
0.0	Clayey silt, some sand, trace gravel, containing organics and rootlets (FILL) Firm Brown Moist	1	SS	5					
218.4 0.8	SILTY PEAT Loose Dark brown Moist becoming wet below a depth of 1.5 m	2	SS	4					
		3	SS	3	OC = 28.4%				
217.0 2.2	SILT, trace to some sand and clay Compact Brown Wet	4	SS	18		0	10	78	12
		5	SS	19					
215.5 3.7	CLAYEY SILT, trace sand, trace gravel Firm to stiff Grey Moist	6	SS	8					
		7	TO	PH	SG = 2.78 C				
		8	SS	13		2	5	61	32
		9	SS	11					
		10	SS	9					
207.0 12.2	CLAYEY SILT with sand, some gravel (TILL) Hard Grey Moist to wet	11	SS	82		20	26	40	14
		12	SS	126					
204.9 14.3	END OF BOREHOLE								



+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No SC-3

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877124.8 ;E 297177.2
BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing
DATE May 23-25, 2012
ORIGINATED BY OS
COMPILED BY NK
CHECKED BY LCC

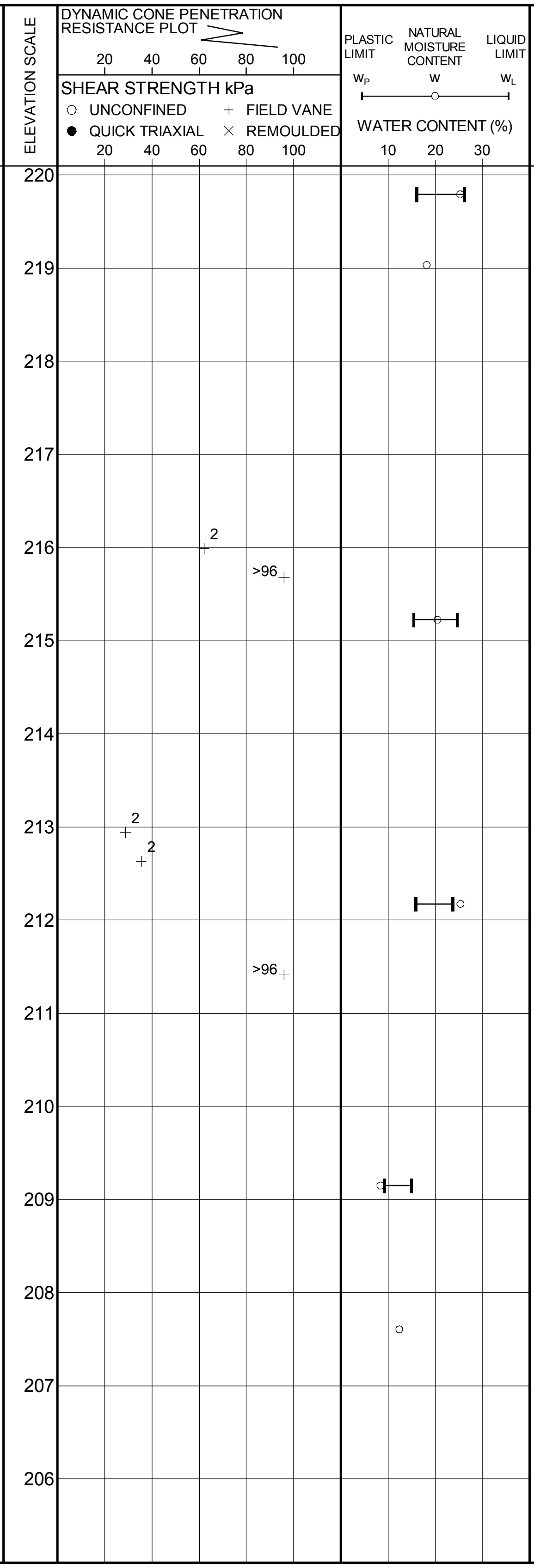
SOIL PROFILE

ELEV DEPTH	DESCRIPTION
220.1	GROUND SURFACE
0.0	TOPSOIL
0.2	Clayey silt with sand to some sand, trace to some gravel, containing rootlets, wood fragments and organics (FILL) Firm to stiff Brown to grey Moist to wet
218.8 1.3	Silty sand, containing wood fragments and organics (FILL) Compact Grey to black Moist
217.4 2.7	CLAYEY SILT, trace to some sand, trace gravel Soft to stiff Grey Moist to wet
210.4 9.7	Silty SAND Grey Moist
209.7 10.4	CLAYEY SILT with sand, some gravel (TILL) Hard Grey Moist
208.4 11.7	SAND and SILT, trace clay Very dense Grey Moist

SAMPLES

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	SS	7						
2A 2B	SS	10						
3	SS	23						
4	SS	14						
5	SS	5						
6	SS	10						
S1	TO	PH		SG = 2.77 C				
7	SS	10						
8	SS	3						
9	SS	20						
10	SS	96			15	39	31	15
11	SS	74			0	50	43	7
12	SS	100/0.08						

REMARKS & GRAIN SIZE DISTRIBUTION (%)



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+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-0018 (URS, YORK REGION)\LOG\0911110018.GPJ GAL-GTA.GDT 01/13/15 SIB

Golder Associates

Foundation Design

RECORD OF BOREHOLE No SC-3

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4877124.8 ;E 297177.2

BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing

DATE May 23-25, 2012

ORIGINATED BY OS

COMPILED BY NK

CHECKED BY LCC

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---													
	SAND and SILT, trace clay Very dense Grey Moist		13	SS	172		205 204		○		0	52	39	9
203.8 16.3	Silty SAND, containing silt seams Very dense Grey Moist		14	SS	212/0.25		203							
202.9 17.2	END OF BOREHOLE NOTES: 1. Artesian groundwater conditions were encountered within the cohesionless soil below a depth of 11.7 m (Elev. 208.4 m). 2. Artesian groundwater level was measured at 3.6 m above ground surface (Elev. 223.7 m) on May 25, 2012, after completion of drilling. 3. Borehole abandoned using cement grout.													

$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-4

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877151.8 ;E 297171.4
BOREHOLE TYPE 108 mm Inside Diameter Hollow Stem Augers
DATE November 17, 18 and 21, 2011
ORIGINATED BY TT
COMPILED BY NK
CHECKED BY LCC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
220.8	GROUND SURFACE							
0.0	Sand and silt to sandy silt, trace clay, trace gravel, containing organics (FILL) Loose to compact Brown, grey and black Moist	1	SS	27				
		2	SS	6				
219.3 1.5	Clayey silt, trace sand, trace gravel, containing organics and silty sand zones (FILL) Firm Grey Moist	3	SS	4				
218.7	Peat (Fibrous becoming amorphous at 2.2 m) Black Moist							
218.4 2.4	SILT, some sand, some clay, containing rootlets, organics and zones of clayey silt Loose to compact Grey Moist	4	SS	9				
		5	SS	10	0	19	69	12
217.1 3.7	CLAYEY SILT, some sand, trace gravel, containing silty sand layers to a depth of 7.2 m Firm to very stiff Grey Moist	6	SS	2				
		7	SS	7				
		8	SS	6	4	26	54	16
		9	SS	17				
		10	SS	6				
		11	SS	1				
		12	SS	7	8	19	53	20
207.4 13.4	Sandy SILT, trace clay, trace gravel, containing gravelly sand layers Very dense Grey Wet	13	SS	56				
206.0 14.8								

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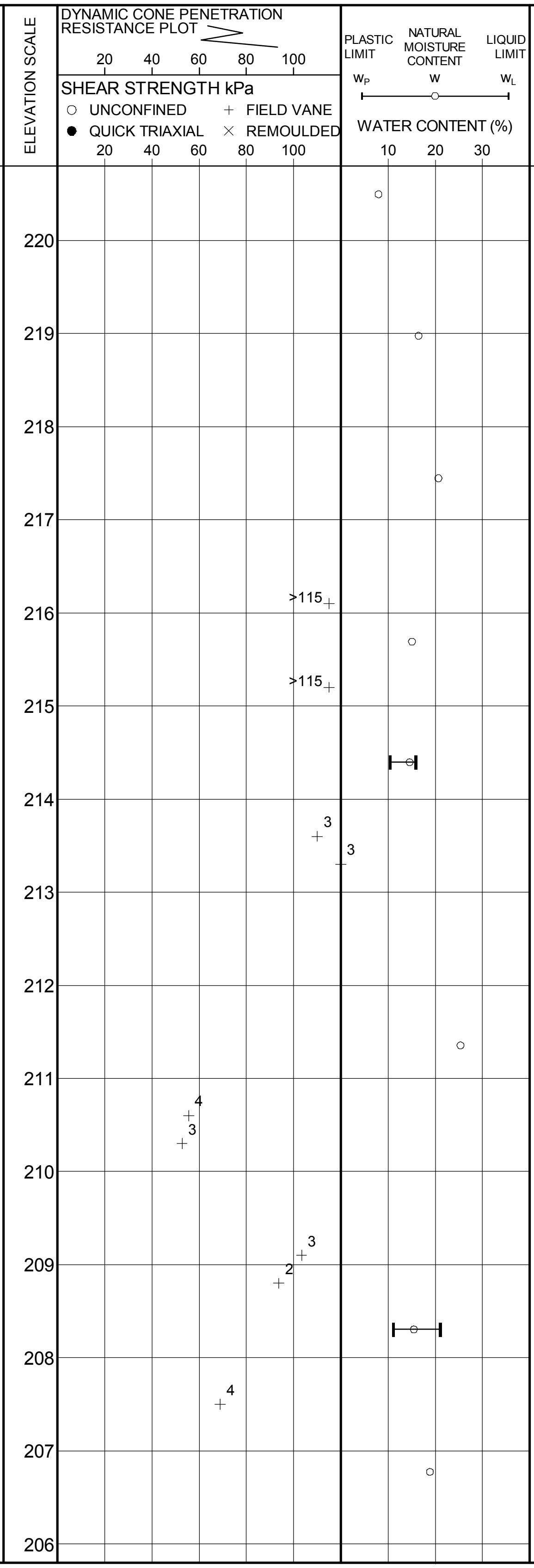


UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-4

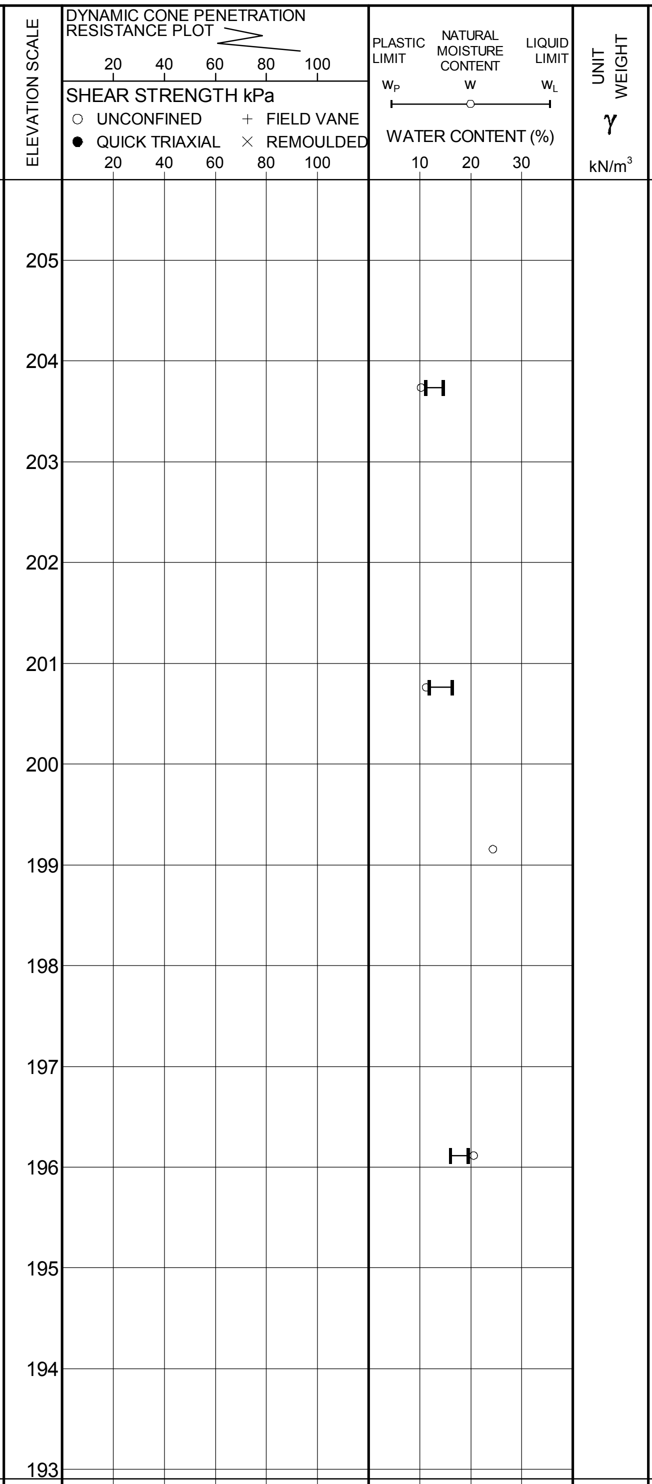
SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877151.8 ;E 297171.4
BOREHOLE TYPE 108 mm Inside Diameter Hollow Stem Augers
DATE November 17, 18 and 21, 2011
ORIGINATED BY TT
COMPILED BY NK
CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	SAND and SILT, trace to some clay, trace gravel (TILL) Very dense Grey Moist	14	SS	107				
		15	SS	92	2	32	56	10
		16	SS	70				
		17	SS	86				
200.6 20.2	Sandy SILT to SILT, trace sand, trace clay Compact to very dense Grey Moist	18	SS	11	0	28	70	2
		19	SS	25				
		20	SS	73	0	1	89	10
195.3 25.5	CLAYEY SILT, trace sand, containing silty sand seams Hard Grey Moist	21	SS	84				
193.8 27.0	SAND and GRAVEL, trace to some silt, trace clay Very dense Grey Wet	22	SS	112				
192.9 27.9	END OF BOREHOLE NOTE: 1. Artesian conditions encountered at a depth of 22.9 m (Elev. 197.9 m). 2. Borehole abandoned using cement grout.							



+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-9

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4877070.2 ;E 297116.5
BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing
DATE May 15 and 16, 2012
ORIGINATED BY OS
COMPILED BY NK
CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
221.0	GROUND SURFACE							
0.0	TOPSOIL							
0.2	Silty SAND, some gravel, trace clay, containing rootlets and organic matter Compact Brown Moist	1	SS	12				
220.4 0.6	CLAYEY SILT, some sand, some gravel, contains rootlets and organic matter, containing peat at a depth of 1.0 m Soft to stiff Grey Moist	2	SS	11				
		3	SS	2				
218.9 2.1	SILT, some sand, trace to some clay Compact Grey Wet	4	SS	25	0	14	74	12
		5	SS	17				
217.3 3.7	CLAYEY SILT, trace sand, trace gravel Stiff to very stiff Grey Moist to wet	6	SS	11				
		7	SS	12				
		8	SS	16	0	0	57	43
		9	SS	23				
		10	SS	15				
210.8 10.2	CLAYEY SILT with to some sand, trace gravel (TILL) Hard Grey Moist	11	SS	68				
		12	SS	78				
		13	SS	68	2	25	48	25

GROUND WATER CONDITIONS

ELEVATION SCALE

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

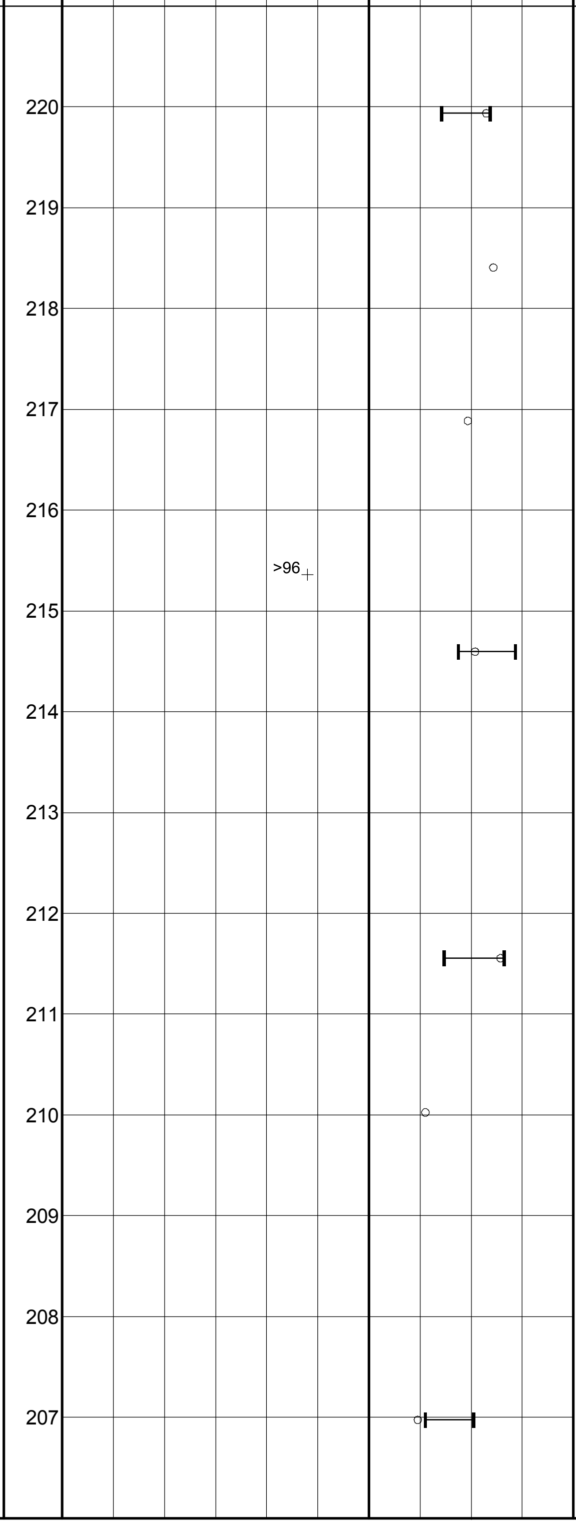
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL



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+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SC-9

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4877070.2 ;E 297116.5

BOREHOLE TYPE D-25 Track Mount, 76 mm Wash Rotary Boring, NW Casing

DATE May 15 and 16, 2012

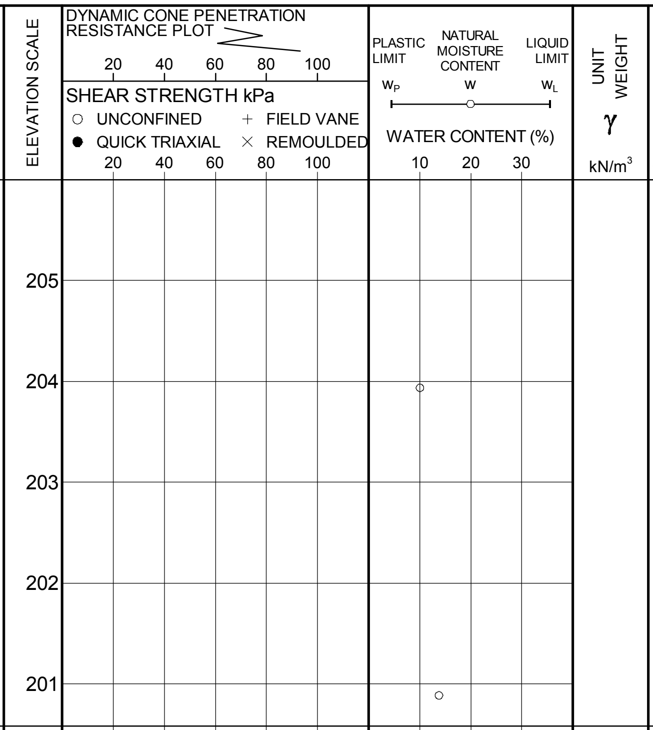
ORIGINATED BY OS

COMPILED BY NK

CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	CLAYEY SILT with to some sand, trace gravel (TILL) Hard Grey Moist	14	SS	104				
		15	SS	96				
202.7 18.5	Silty SAND Grey Wet	16	SS	99				
201.6 19.4	CLAYEY SILT with sand, some gravel (TILL) Hard Grey Wet							
200.6 20.4	SAND, some silt, trace gravel, trace clay Very dense Grey Wet	17	SS	113	5	77	14	4
	END OF BOREHOLE							



NOTES:

1. Artesian groundwater conditions were encountered within the cohesionless soil below a depth of 18.3 m (Elev. 202.7 m) during drilling operations

2. Artesian groundwater level was measured at 4.1 m above ground surface (Elev. 225.1 m) on May 16, 2012.

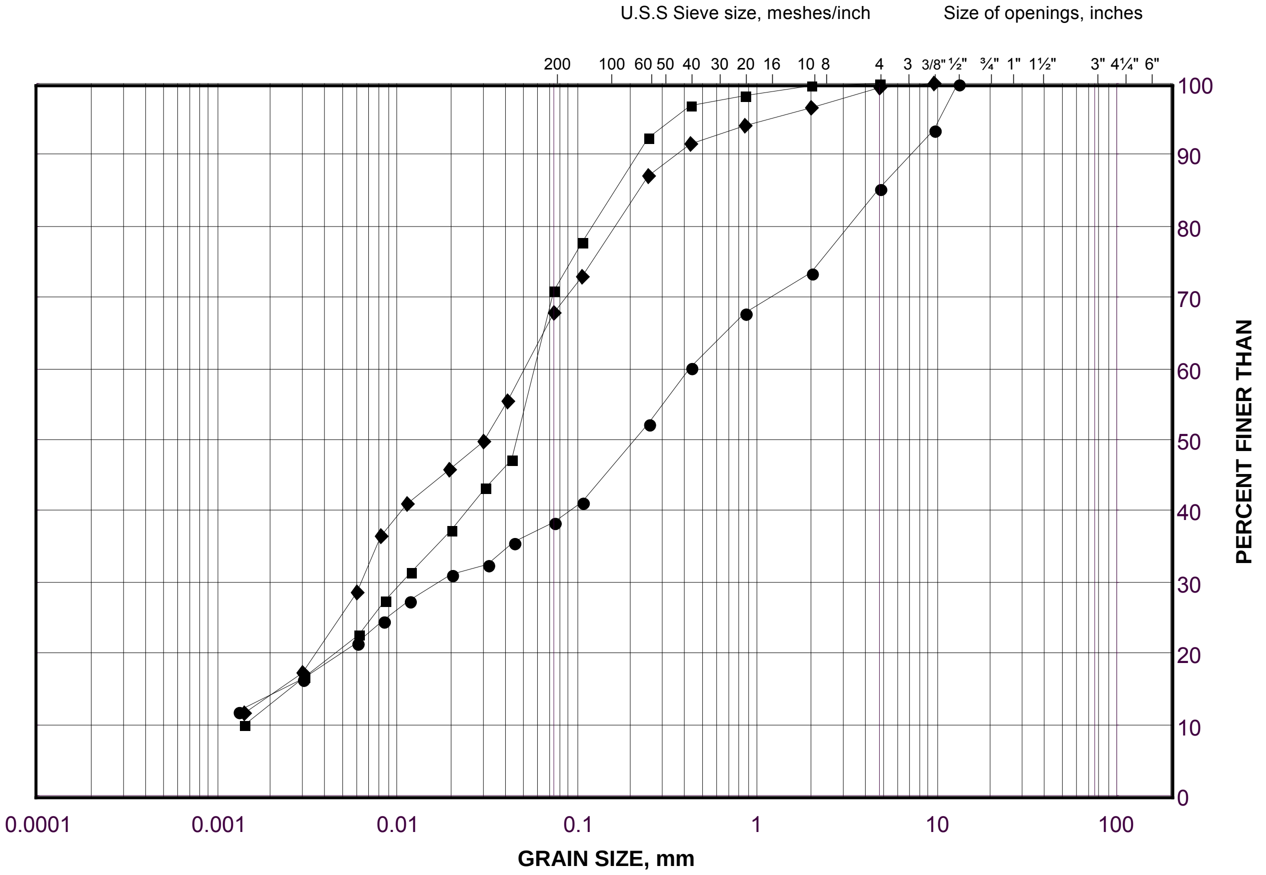
3. Borehole abandoned using cement grout.

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

GRAIN SIZE DISTRIBUTION

Clayey Silt Fill

FIGURE C1



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-12	4	216.4
■	12-11	4A	217.0
◆	12-11	5	216.2

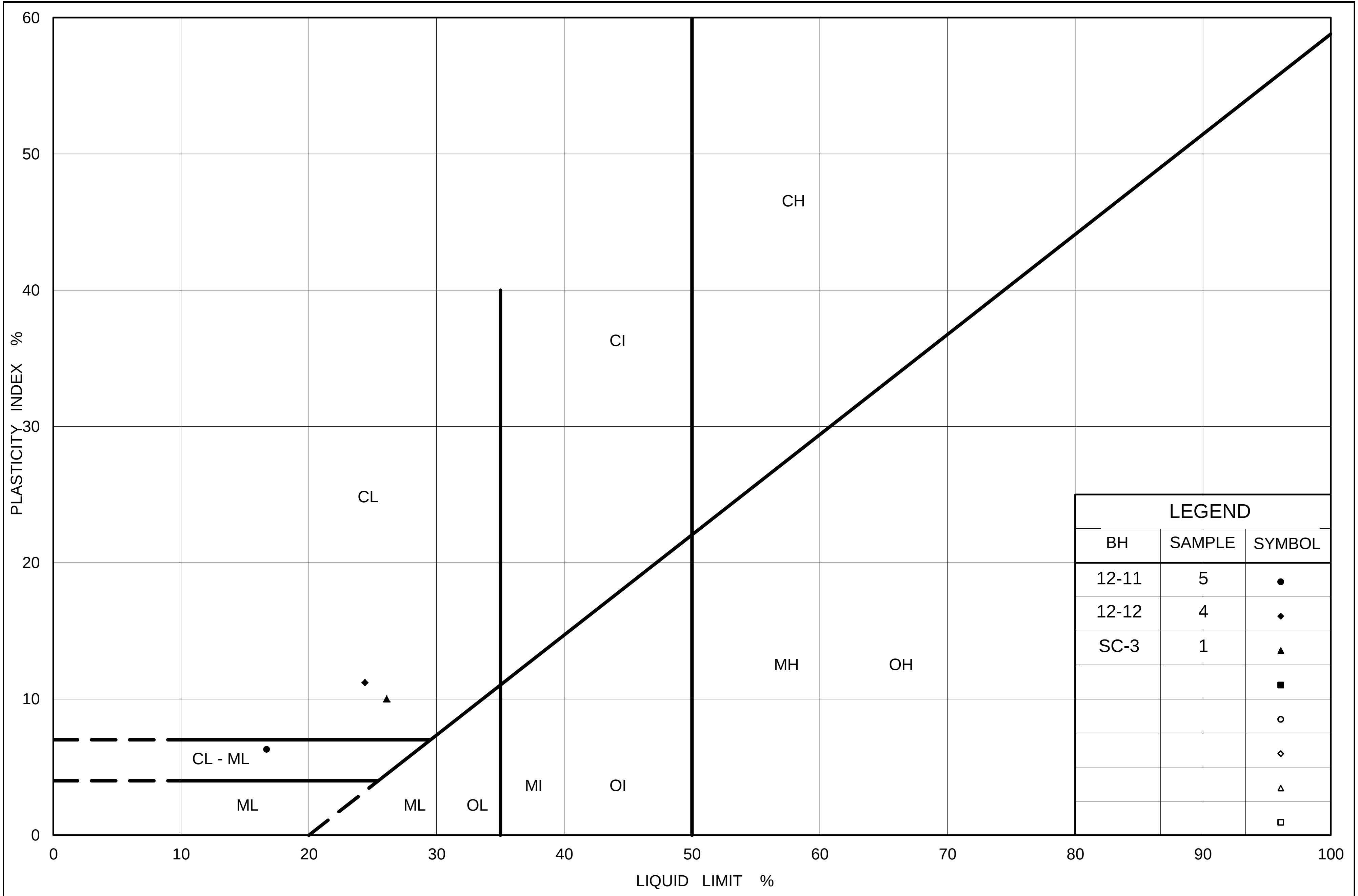
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 25-Jan-13

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt Fill

Figure No. C2

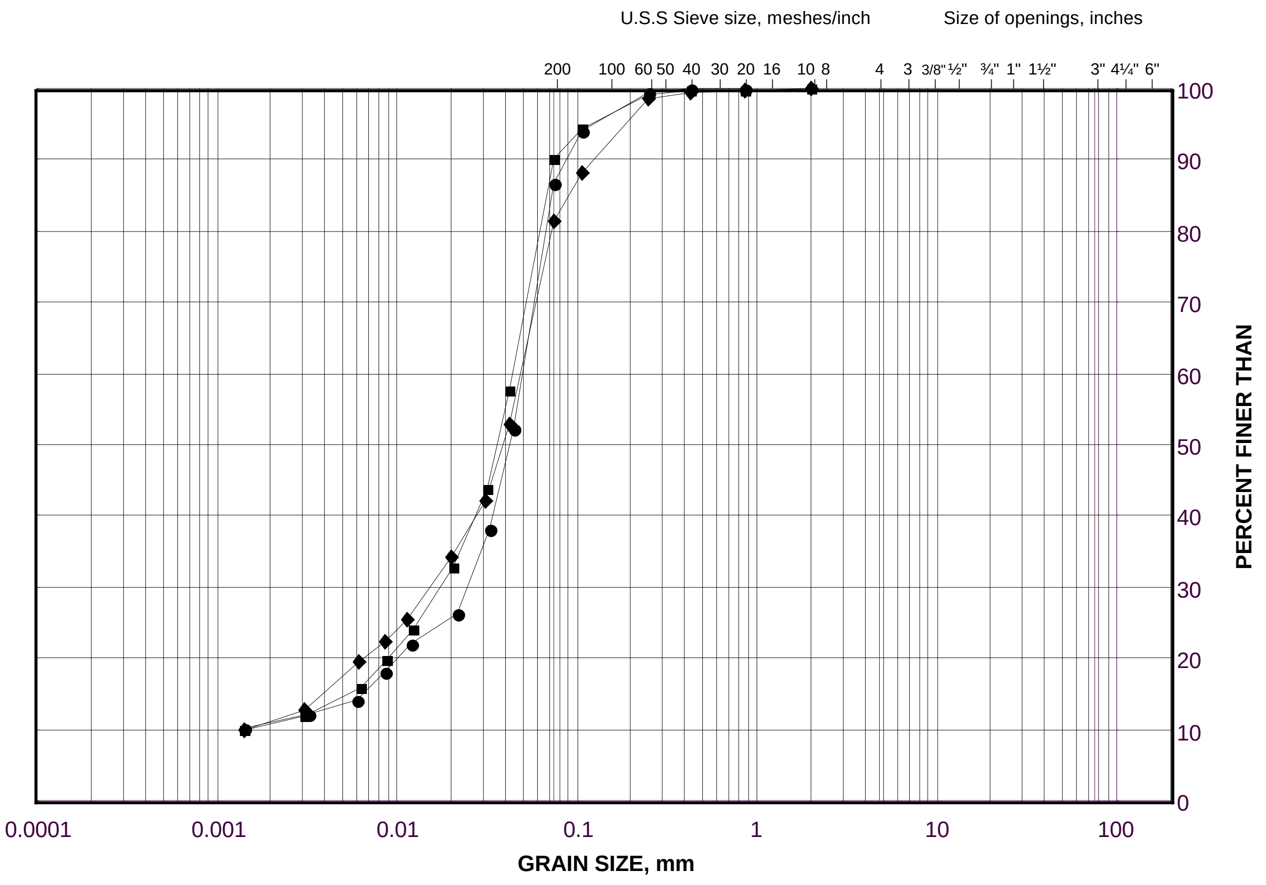
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Silt (Upper Deposit)

FIGURE C3



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-9	4	218.4
■	12-14	4	216.6
◆	SC-4	5	217.5

Project Number: 09-1111-0018

Checked By: LCC

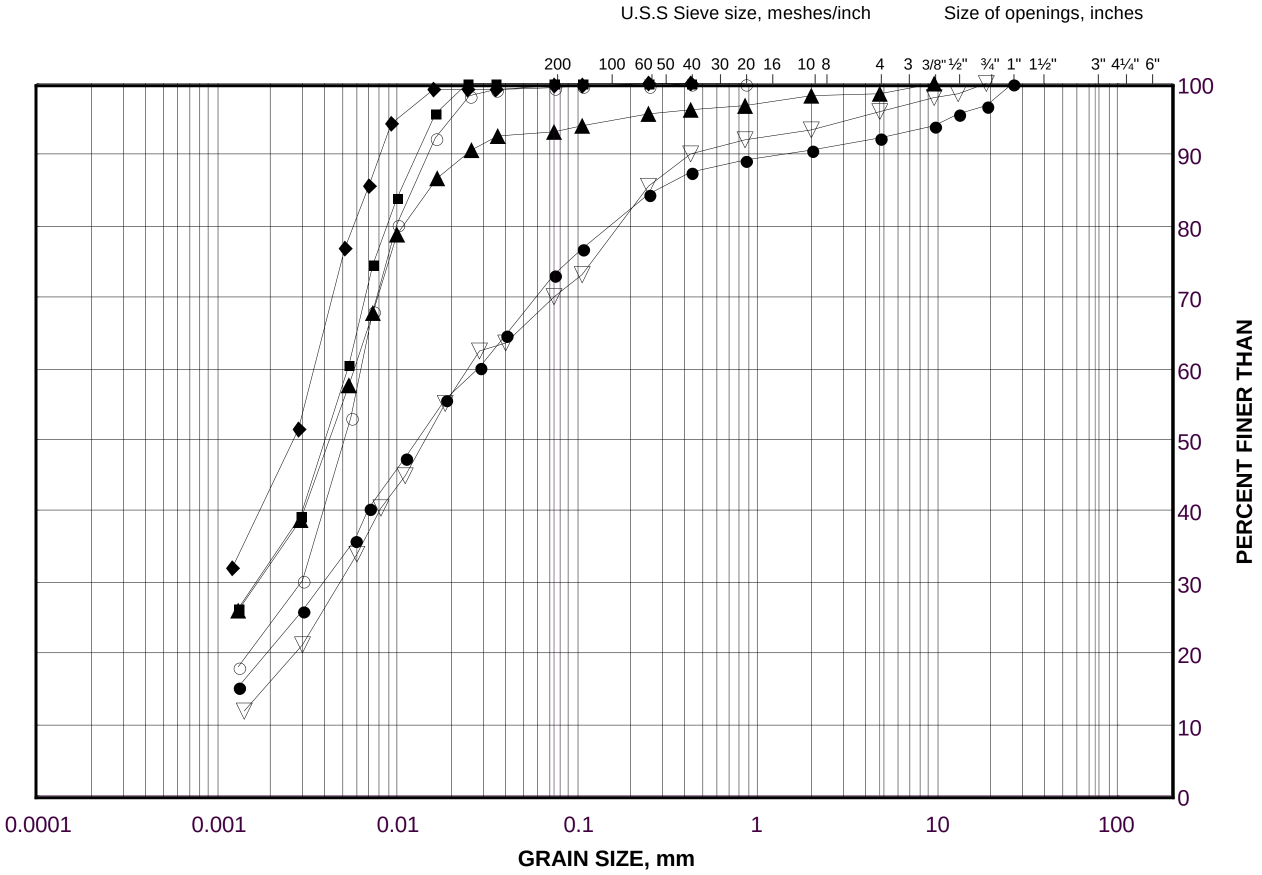
Golder Associates

Date: 10-Jul-13

GRAIN SIZE DISTRIBUTION

Clayey Silt (Upper Deposit)

FIGURE C4



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-4	12	208.3
■	12-13	6	215.2
◆	SC-9	8	214.6
▲	12-14	8	211.3
▽	SC-4	8	214.4
○	12-12	9	211.1

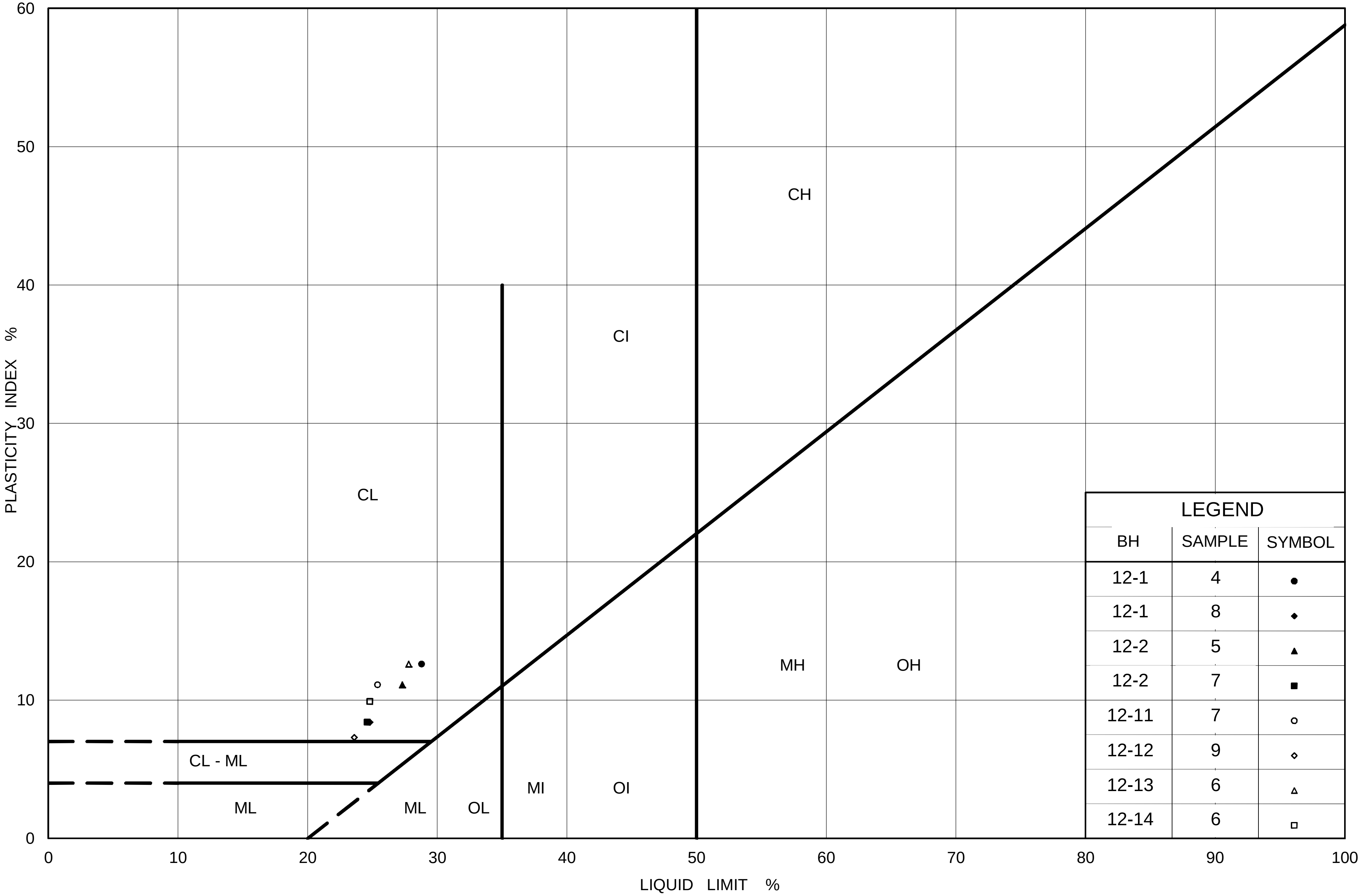
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 08-Feb-13

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
12-1	4	●
12-1	8	◆
12-2	5	▲
12-2	7	■
12-11	7	○
12-12	9	◇
12-13	6	△
12-14	6	□

Ministry of Transportation

Ontario

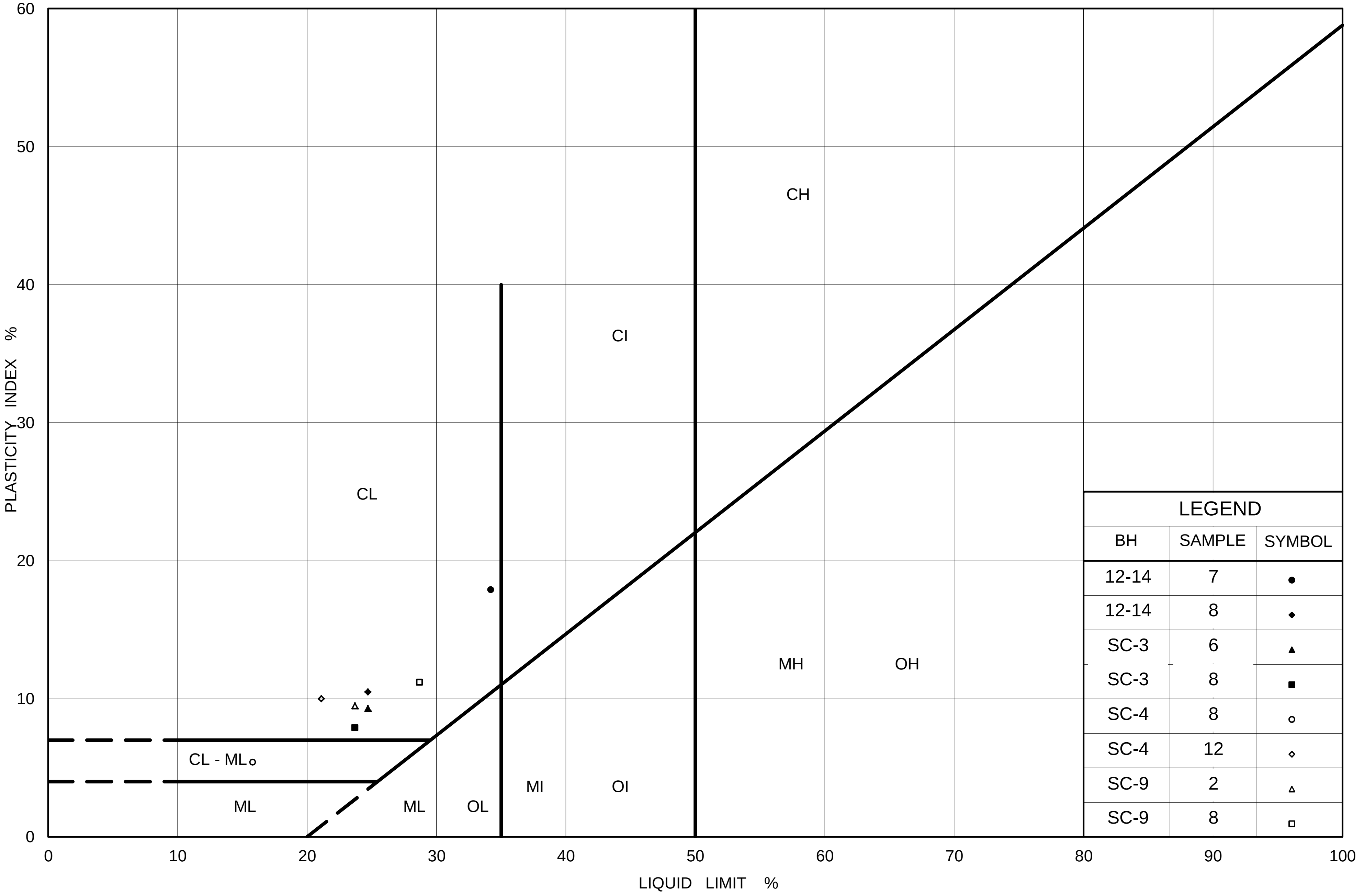
PLASTICITY CHART
Clayey Silt (Upper Deposit)

Figure No. C5A

Project No. 09-1111-0018

Checked By: LCC

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
12-14	7	●
12-14	8	◆
SC-3	6	▲
SC-3	8	■
SC-4	8	○
SC-4	12	◇
SC-9	2	△
SC-9	8	□

Ministry of Transportation

Ontario

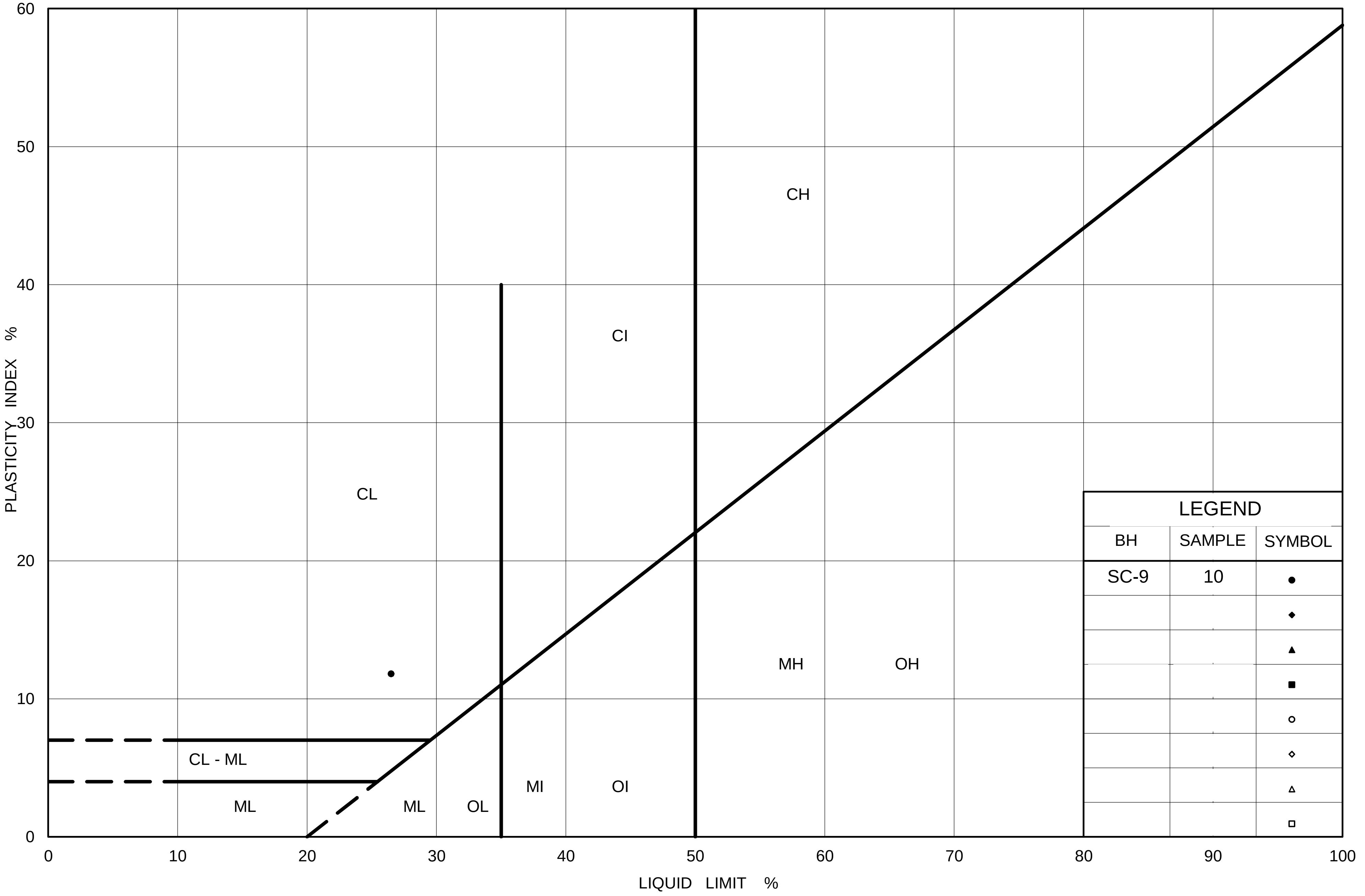
PLASTICITY CHART
Clayey Silt (Upper Deposit)

Figure No. C5B

Project No. 09-1111-0018

Checked By: LCC

Oct 75, FF-S-21



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PLASTICITY CHART
Clayey Silt (Upper Deposit)

Figure No. C5C

Project No. 09-1111-0018

Checked By: LCC

CONSOLIDATION TEST SUMMARY

FIGURE C6
Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-0018	Sample Number	7
Borehole Number	12-14	Sample Depth, m	6.10-6.55

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	10		
Date Started	06/11/2012		
Date Completed	06/28/2012		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.54	Unit Weight, kN/m^3	20.56
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	16.57
Area, cm^2	31.53	Specific Gravity, measured	2.78
Volume, cm^3	80.02	Solids Height, cm	1.543
Water Content, %	24.06	Volume of Solids, cm^3	48.64
Wet Mass, g	167.76	Volume of Voids, cm^3	31.38
Dry Mass, g	135.23	Degree of Saturation, %	103.7

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.538	0.645	2.538				
6.00	2.536	0.644	2.537	265	5.15E-03	1.31E-04	6.63E-08
10.67	2.535	0.643	2.536	1354	1.01E-03	6.75E-05	6.66E-09
20.61	2.527	0.638	2.531	1270	1.07E-03	3.37E-04	3.53E-08
39.98	2.514	0.629	2.520	960	1.40E-03	2.66E-04	3.66E-08
78.89	2.495	0.617	2.504	522	2.55E-03	1.90E-04	4.75E-08
118.01	2.482	0.609	2.489	1009	1.30E-03	1.26E-04	1.61E-08
156.46	2.472	0.602	2.477	913	1.42E-03	1.08E-04	1.50E-08
310.07	2.436	0.579	2.454	540	2.36E-03	9.21E-05	2.13E-08
620.12	2.387	0.547	2.412	470	2.62E-03	6.18E-05	1.59E-08
1241.22	2.324	0.506	2.356	487	2.42E-03	4.02E-05	9.52E-09
2484.03	2.253	0.460	2.289	252	4.41E-03	2.24E-05	9.69E-09
1241.22	2.257	0.463	2.255				
310.07	2.292	0.485	2.274				
78.89	2.329	0.509	2.310				
20.61	2.363	0.532	2.346				
5.90	2.385	0.546	2.374				

Note:
k calculated using cv based on t_{90} values.

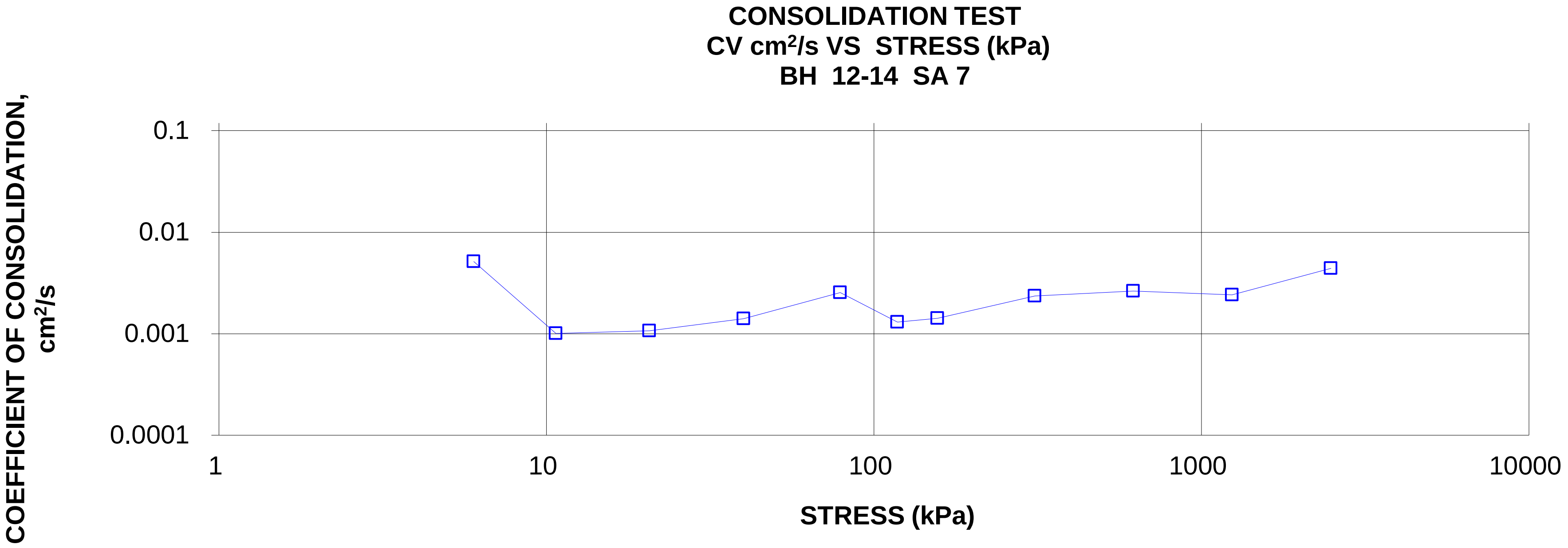
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

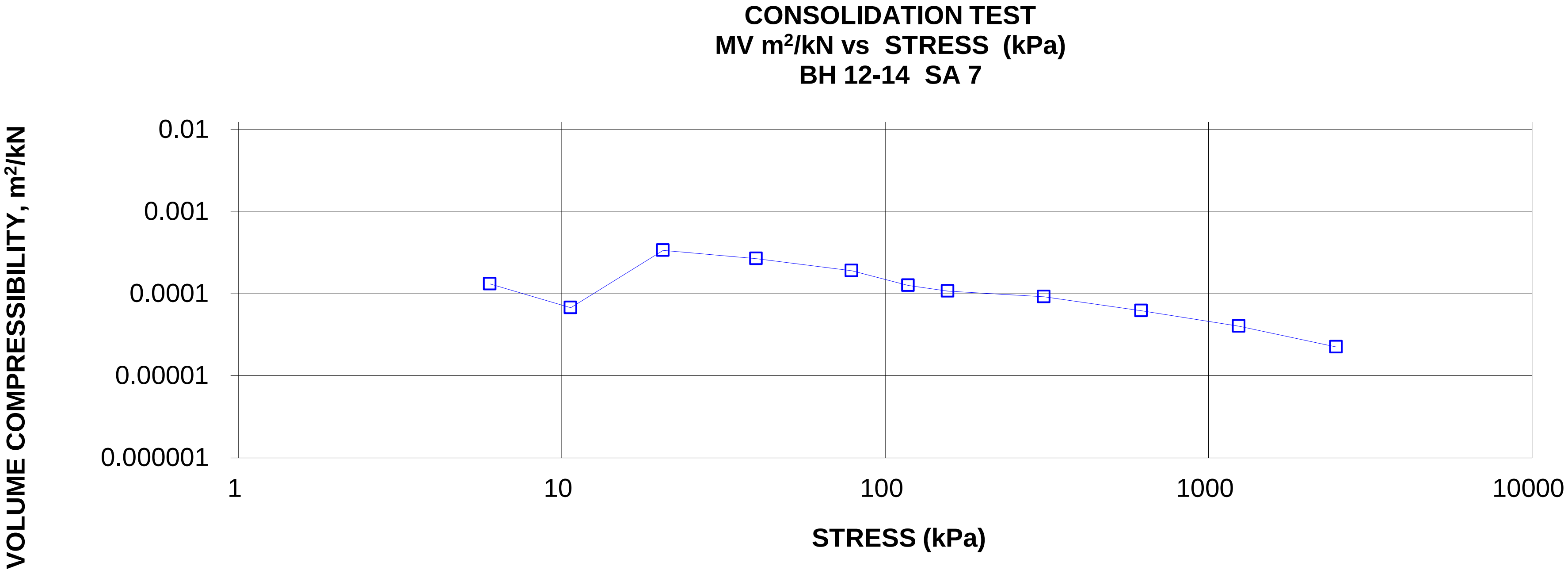
Sample Height, cm	2.39	Unit Weight, kN/m^3	21.43
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	17.63
Area, cm^2	31.53	Specific Gravity, measured	2.78
Volume, cm^3	75.20	Solids Height, cm	1.543
Water Content, %	21.53	Volume of Solids, cm ^{3}	48.64
Wet Mass, g	164.35	Volume of Voids, cm ^{3}	26.56
Dry Mass, g	135.23		

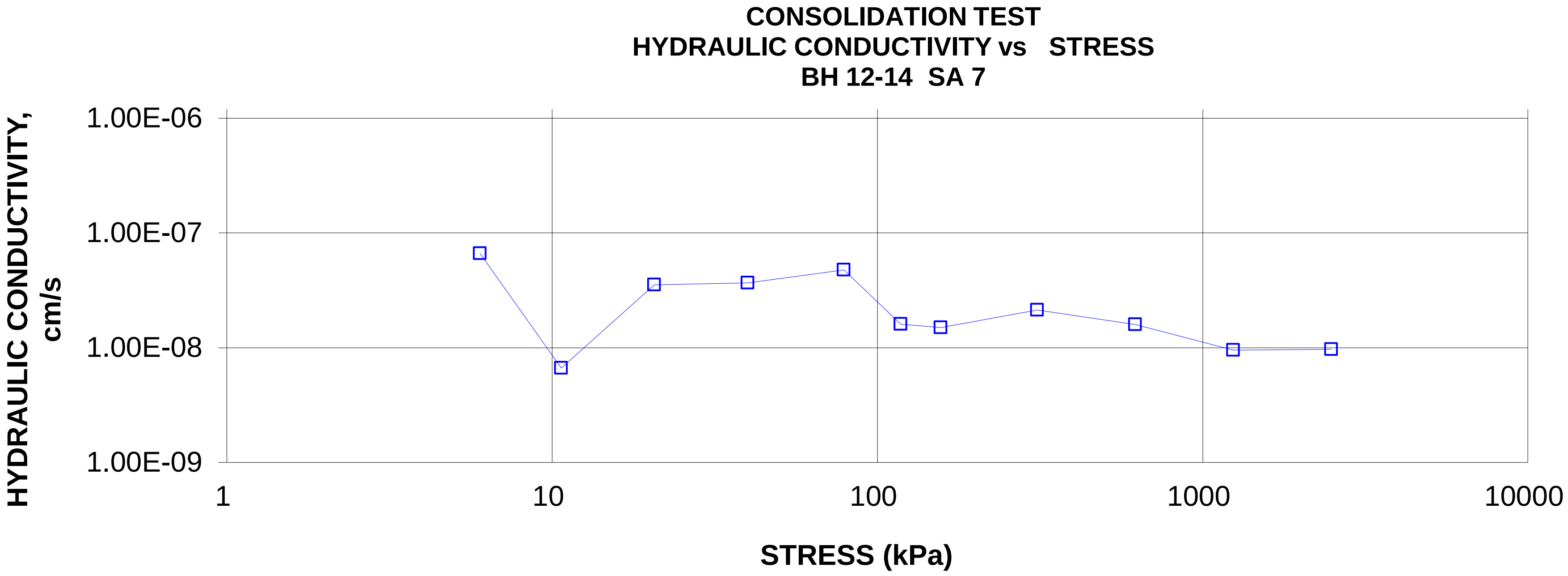
Prepared By: LH **Golder Associates** Checked By: LCC

CONSOLIDATION TEST SUMMARY

FIGURE C6
Sheet 2 of 4







Project No. 09-1111-0018

Prepared By: LH

Golder Associates

Checked By: LCC

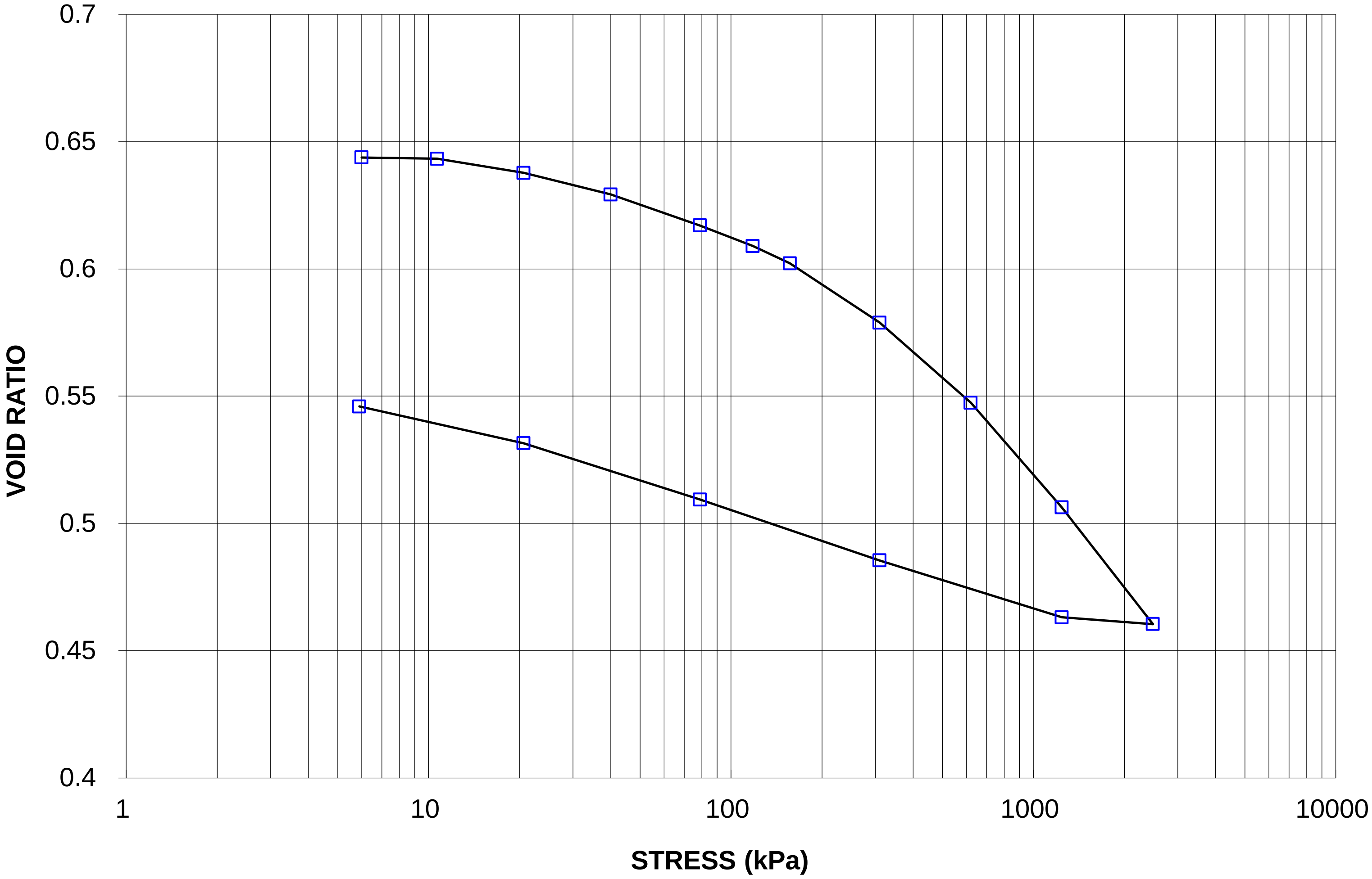
Project No. 09-1111-0018

Prepared By: LH

Golder Associates

Checked By: LCC

CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 12-14 SA 7



CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE C6
Sheet 3 of 4

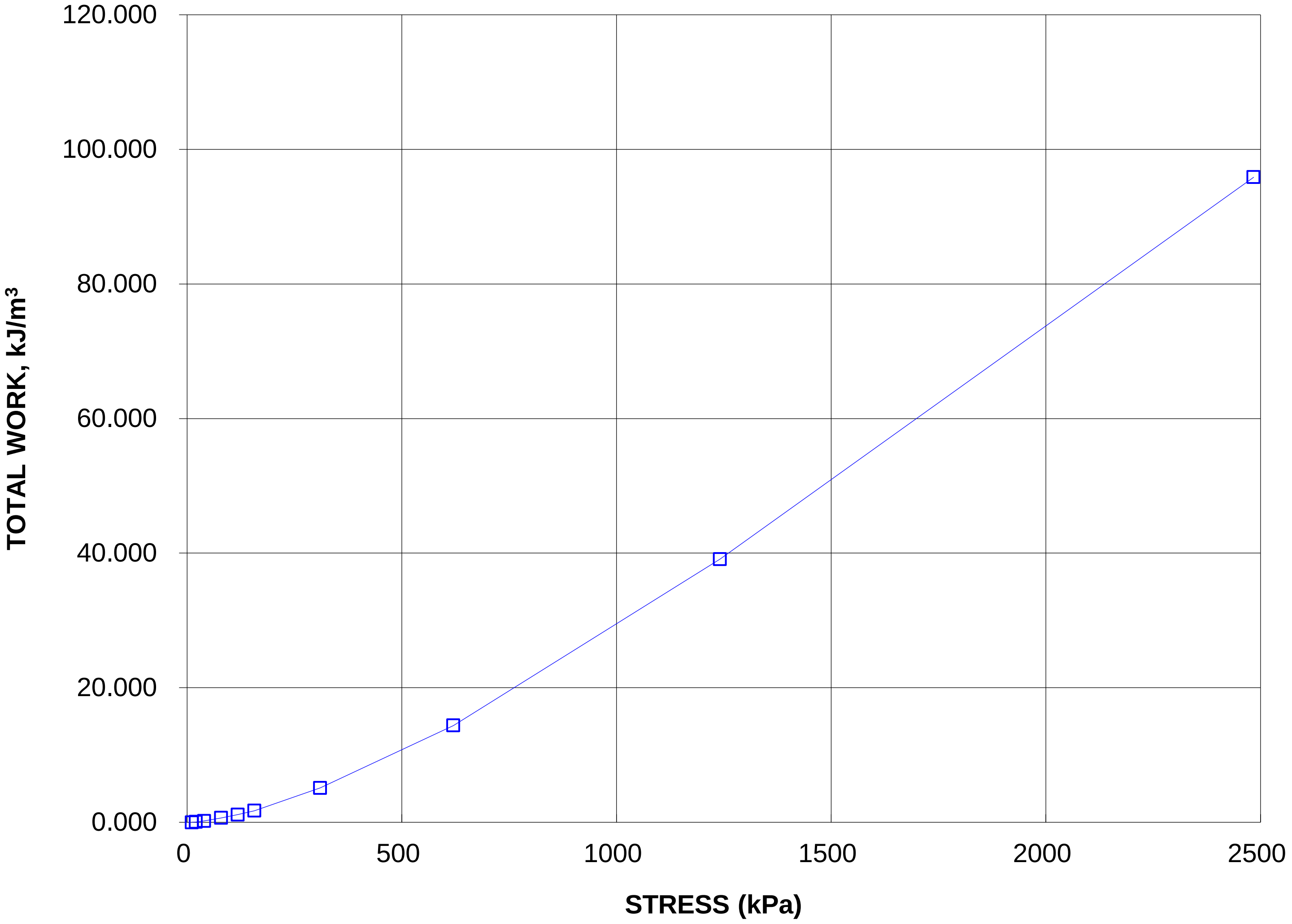
Project No. 09-1111-0018

Prepared By: LH

Golder Associates

Checked By: LCC

CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs STRESS
BH12-14 SA 7



CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE C6
Sheet 4 of 4

CONSOLIDATION TEST SUMMARY

FIGURE C7
Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-0018	Sample Number	S1
Borehole Number	SC-3	Sample Depth, m	5.34-5.79

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	12		
Date Started	06/20/2012		
Date Completed	07/05/2012		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.55	Unit Weight, kN/m^3	20.74
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	16.56
Area, cm^2	31.58	Specific Gravity, measured	2.77
Volume, cm^3	80.46	Solids Height, cm	1.553
Water Content, %	25.28	Volume of Solids, cm^3	49.04
Wet Mass, g	170.18	Volume of Voids, cm^3	31.42
Dry Mass, g	135.84	Degree of Saturation, %	109.3

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.548	0.641	2.548				
5.97	2.524	0.625	2.536	1411	9.66E-04	1.60E-03	1.52E-07
10.77	2.516	0.620	2.520	1782	7.55E-04	6.46E-04	4.78E-08
20.51	2.502	0.611	2.509	1156	1.15E-03	5.40E-04	6.11E-08
39.99	2.486	0.601	2.494	454	2.90E-03	3.30E-04	9.41E-08
78.32	2.463	0.586	2.474	265	4.90E-03	2.38E-04	1.14E-07
156.28	2.436	0.569	2.449	252	5.05E-03	1.35E-04	6.67E-08
311.94	2.400	0.545	2.418	217	5.71E-03	9.18E-05	5.14E-08
622.06	2.356	0.517	2.378	228	5.26E-03	5.49E-05	2.83E-08
1241.34	2.306	0.485	2.331	240	4.80E-03	3.18E-05	1.50E-08
2481.97	2.249	0.448	2.277	104	1.06E-02	1.81E-05	1.87E-08
1241.34	2.253	0.451	2.251				
311.94	2.275	0.465	2.264				
78.32	2.301	0.482	2.288				
20.51	2.324	0.496	2.313				
6.04	2.343	0.509	2.334				

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

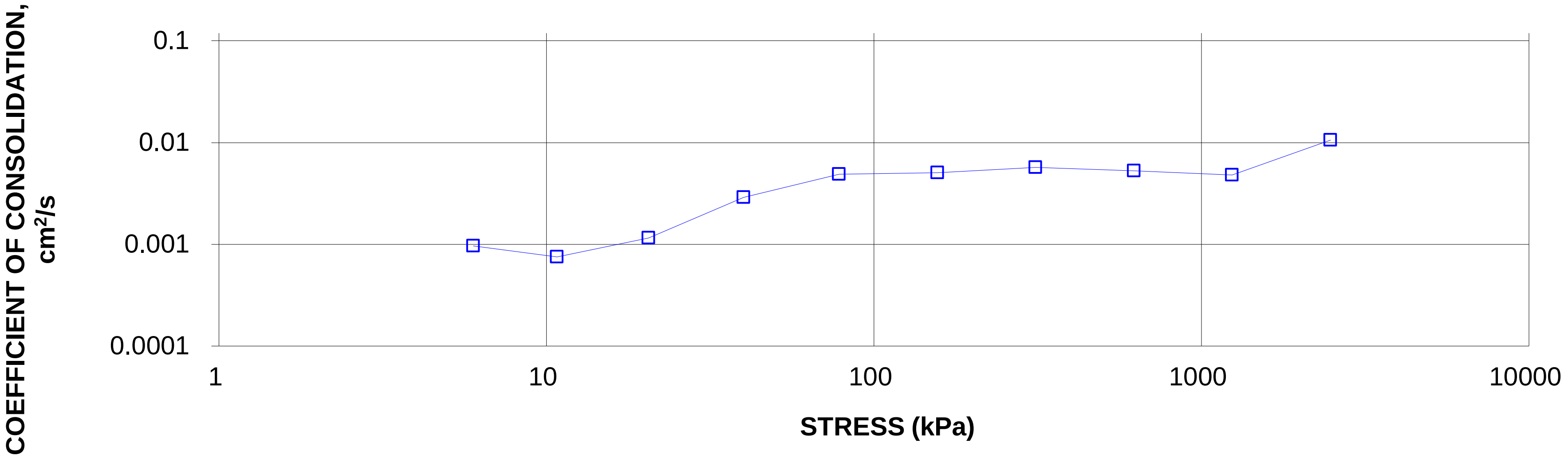
Sample Height, cm	2.34	Unit Weight, kN/m^3	21.73
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	18.00
Area, cm^2	31.58	Specific Gravity, measured	2.77
Volume, cm^3	74.00	Solids Height, cm	1.553
Water Content, %	20.69	Volume of Solids, cm ^{3}	49.04
Wet Mass, g	163.94	Volume of Voids, cm ^{3}	24.96
Dry Mass, g	135.84		

Prepared By: LH **Golder Associates** Checked By: LCC

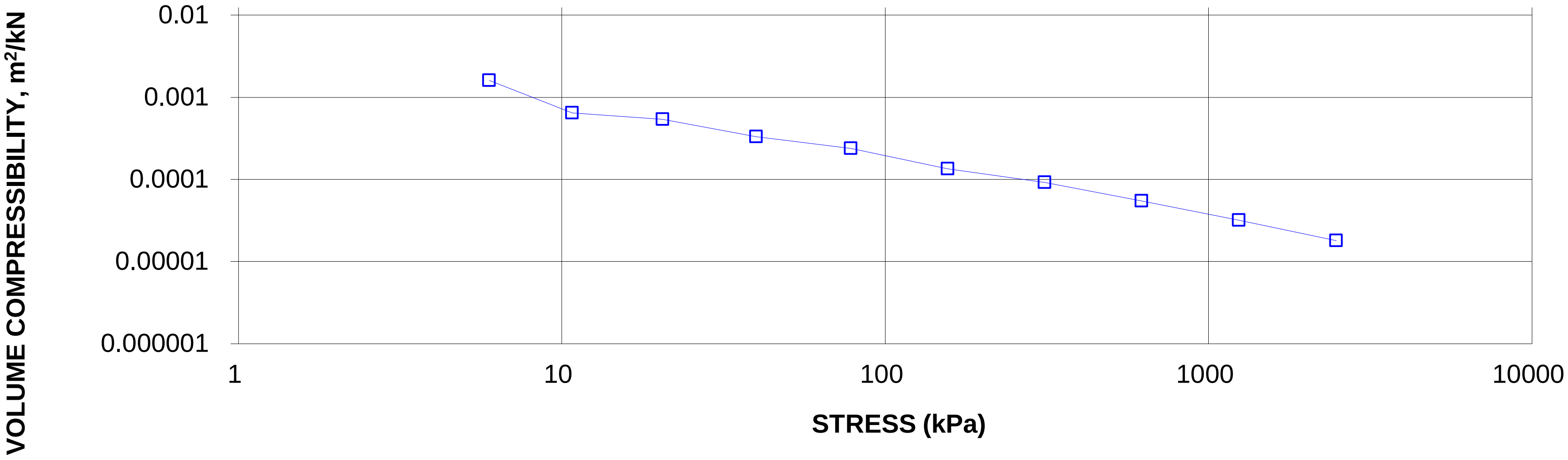
CONSOLIDATION TEST SUMMARY

FIGURE C7
Sheet 2 of 4

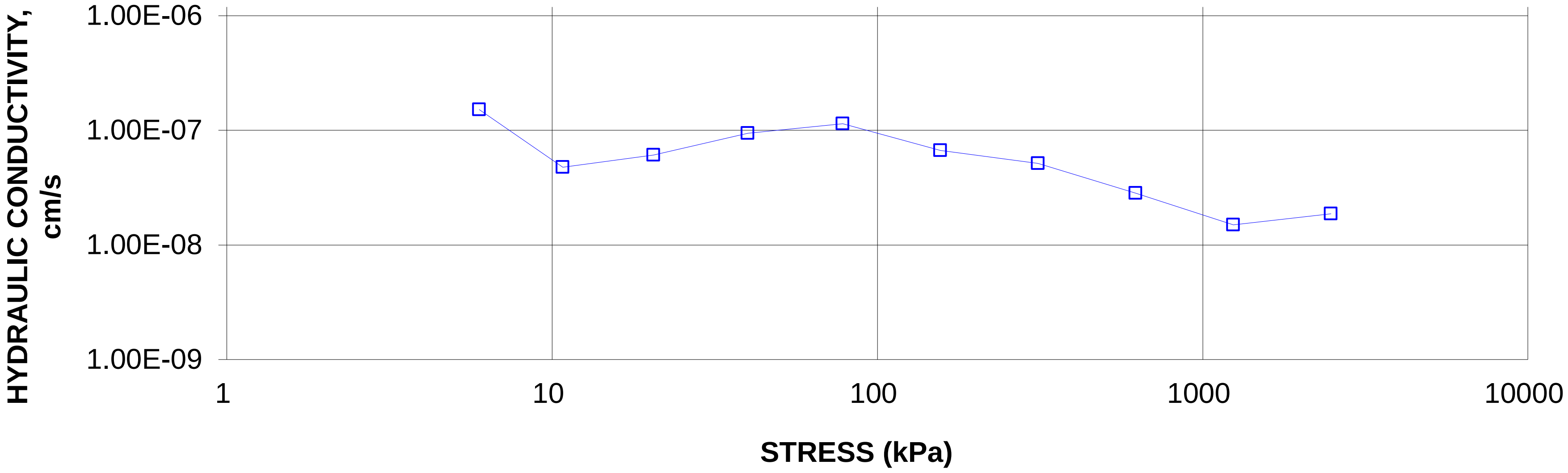
CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
BH SC-3 SA S1



CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
BH SC-3 SA S1



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH SC-3 SA S1



Project No. 09-1111-0018
Prepared By: LH

Golder Associates

Checked By: LCC

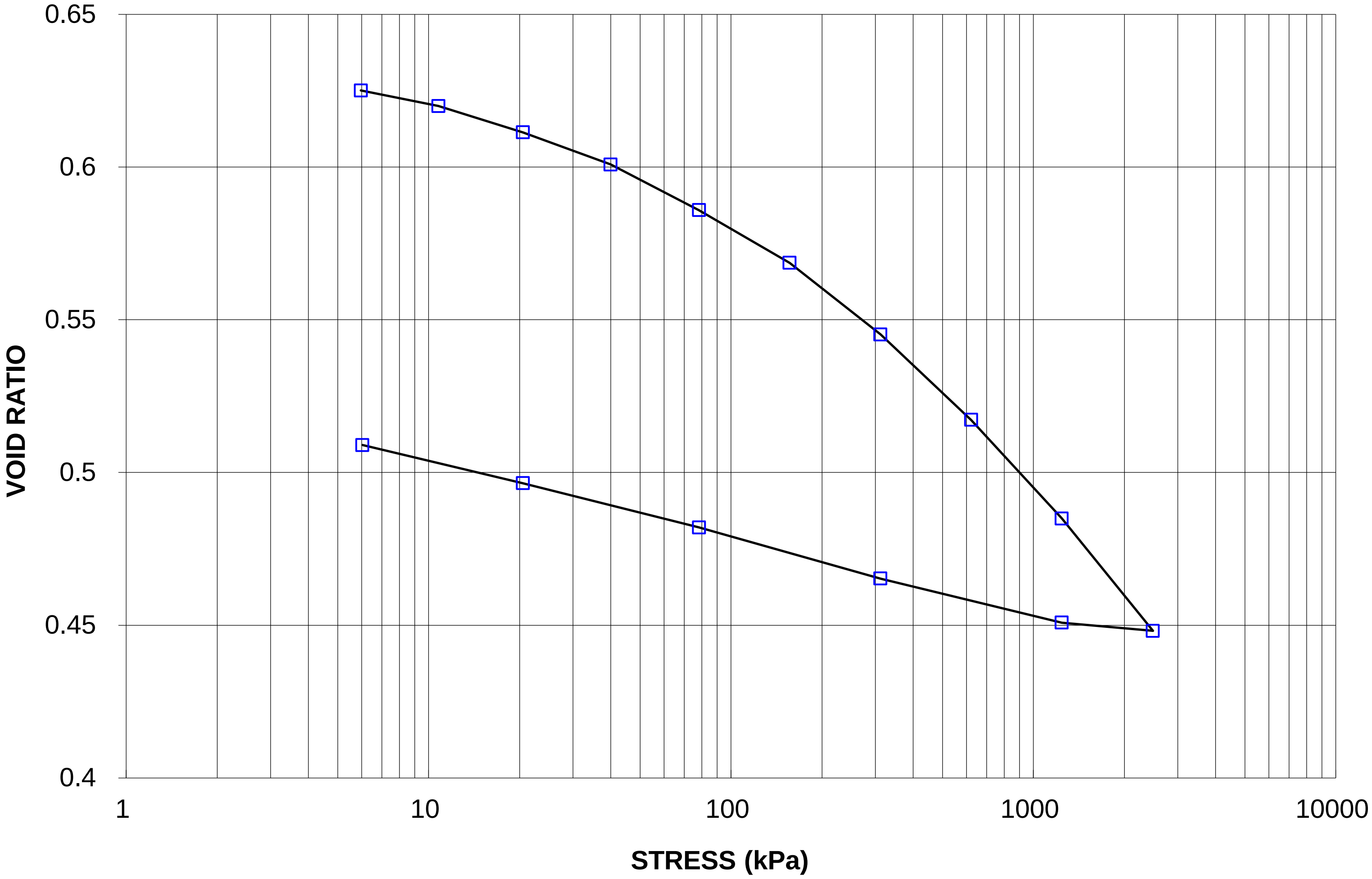
Project No.09-1111-0018

Prepared By: LH

Golder Associates

Checked By: LCC

CONSOLIDATION TEST
VOID RATIO vs STRESS
BH SC-3 SA S1



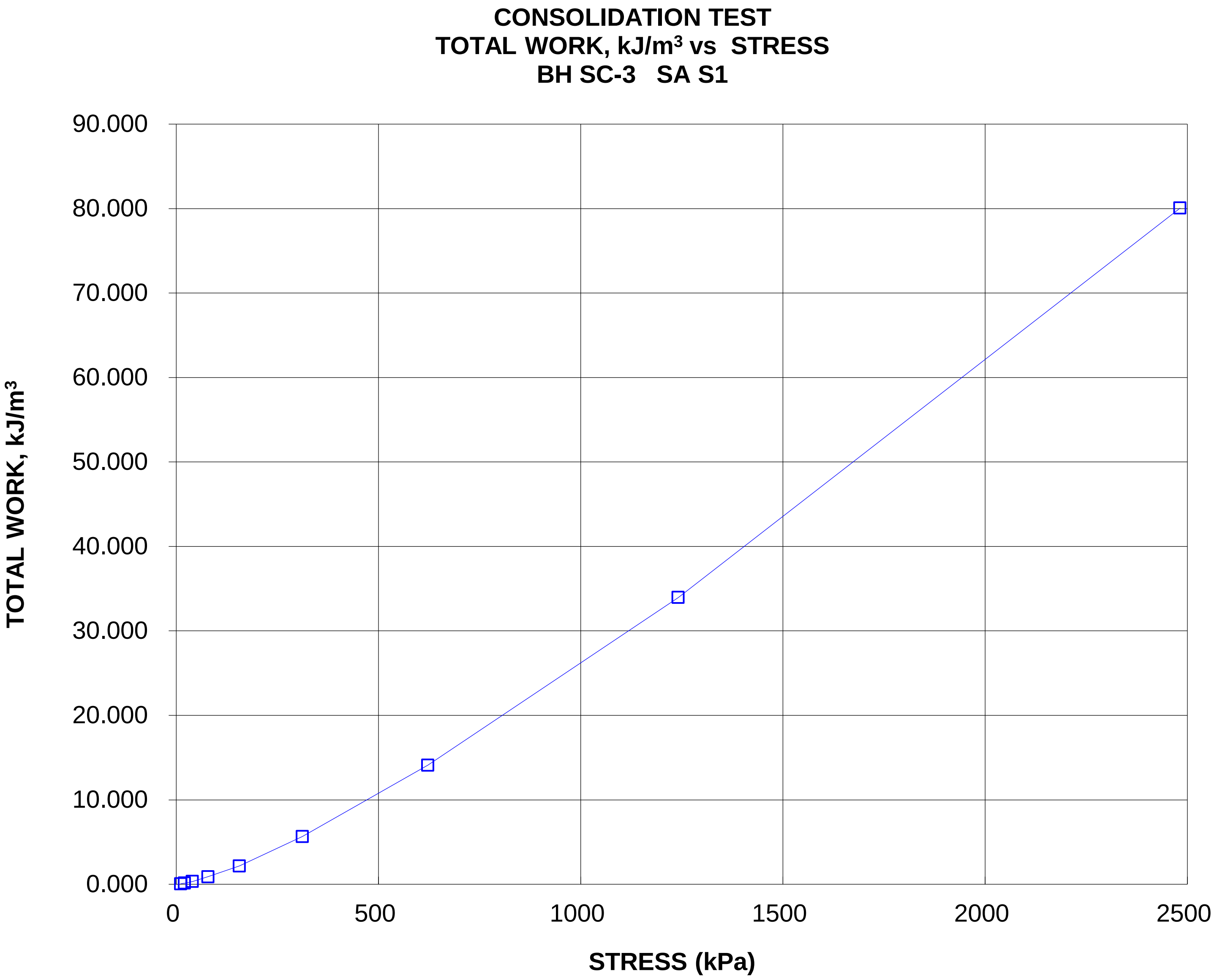
CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE C7
Sheet 3 of 4

Project No.09-1111-0018

Prepared By: LH

Golder Associates

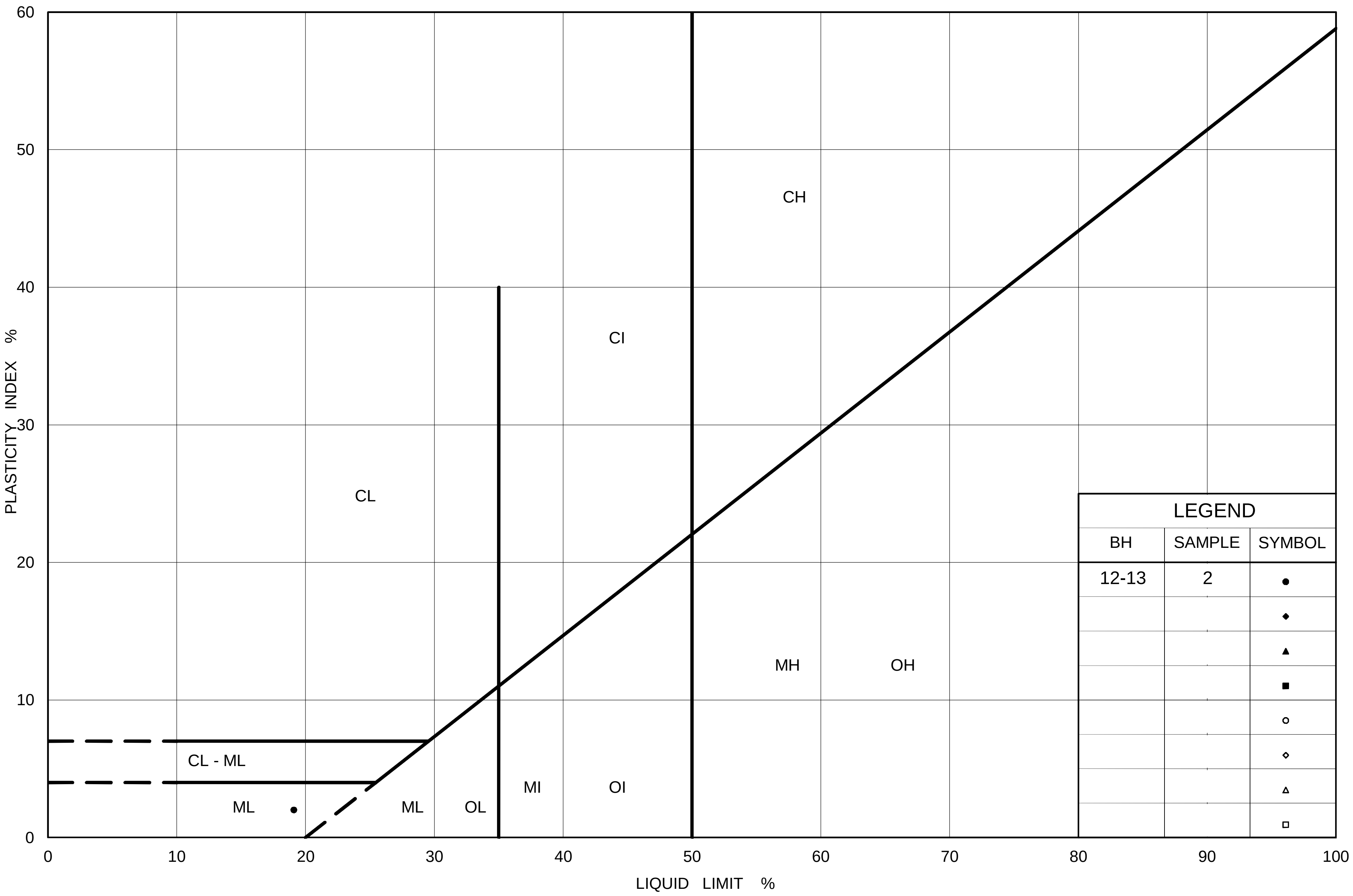


Checked By: LCC

CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE C7
Sheet 4 of 4

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt (Interlayers)

Figure No. C8

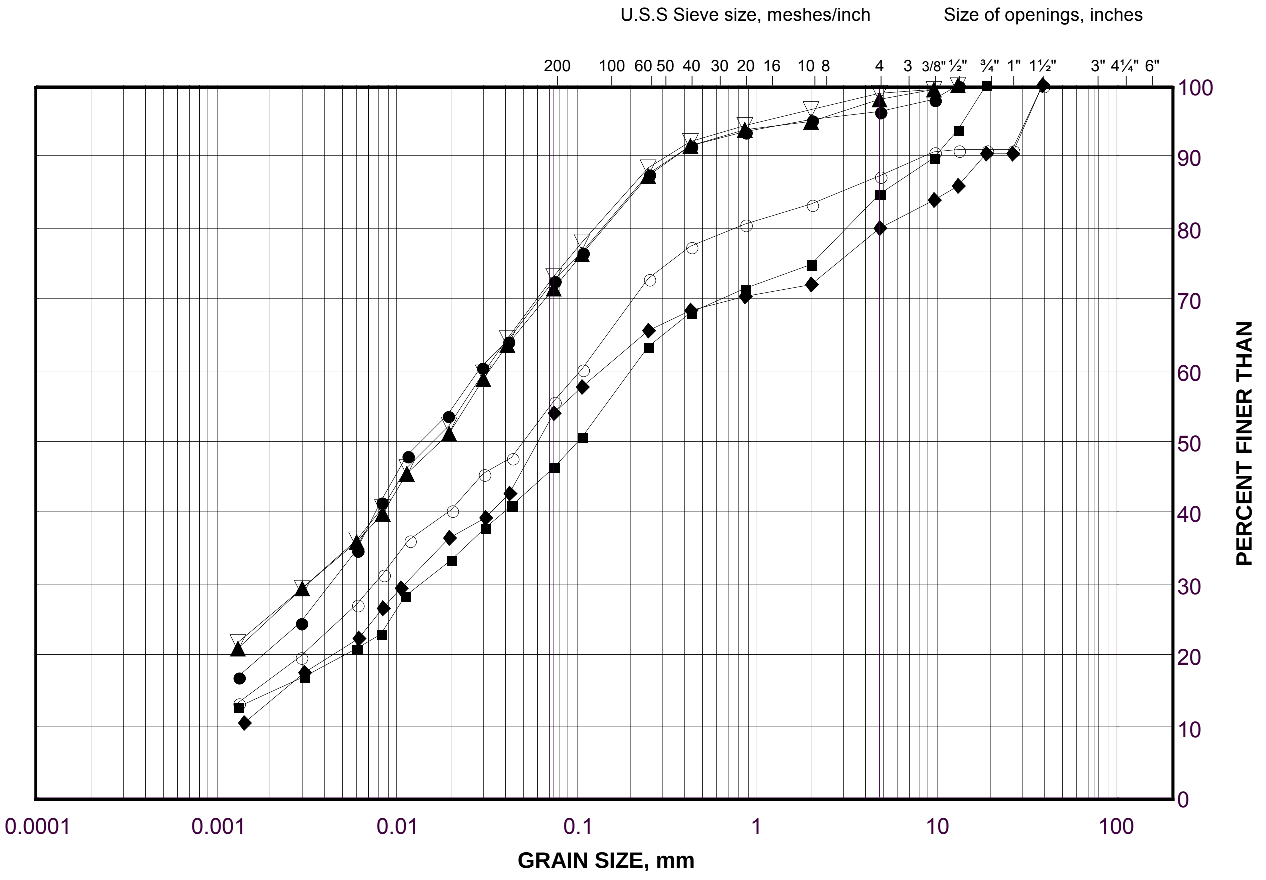
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE C9



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-1	10	206.8
■	SC-3	10	209.2
◆	12-14	11	206.8
▲	12-13	12	206.8
▽	SC-9	13	207.0
○	12-2	9	208.7

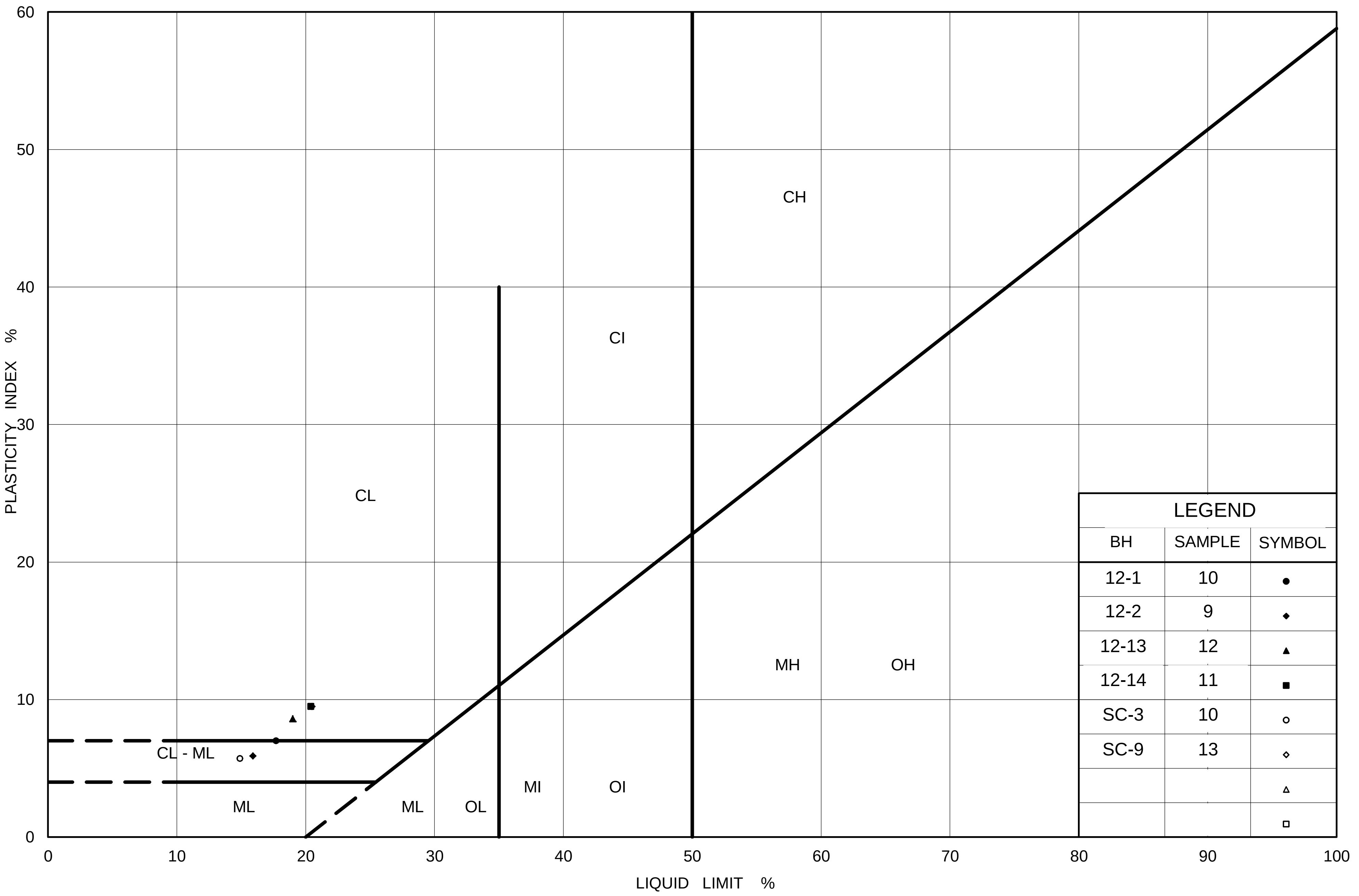
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 25-Jan-13

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
12-1	10	●
12-2	9	◆
12-13	12	▲
12-14	11	■
SC-3	10	○
SC-9	13	◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt Till

Figure No. C10

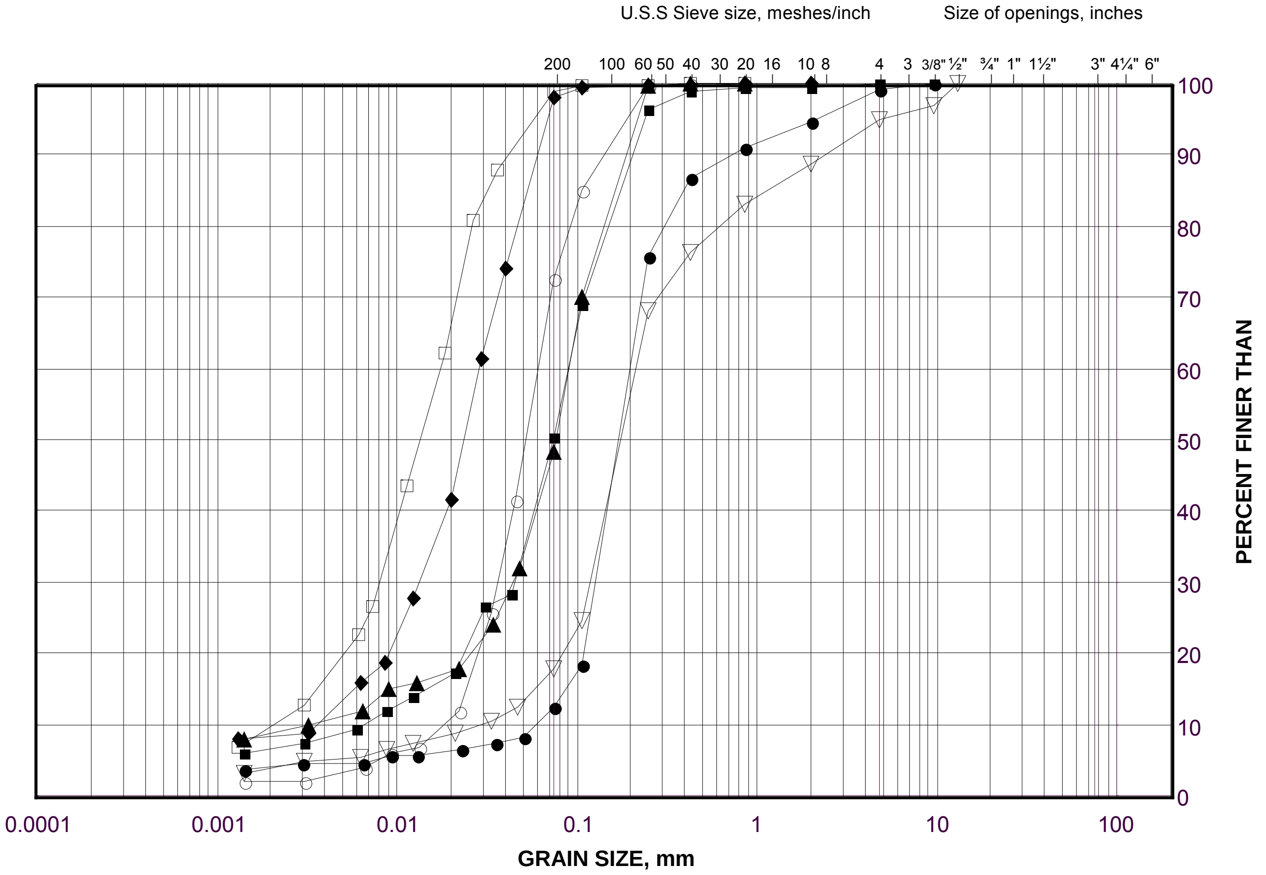
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Silt to Sand

FIGURE C11



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-2	11	205.6
■	SC-3	11	207.7
◆	12-12	11	208.0
▲	SC-3	13	204.6
▽	SC-9	17	200.9
○	SC-4	18	199.1
□	SC-4	20	196.1

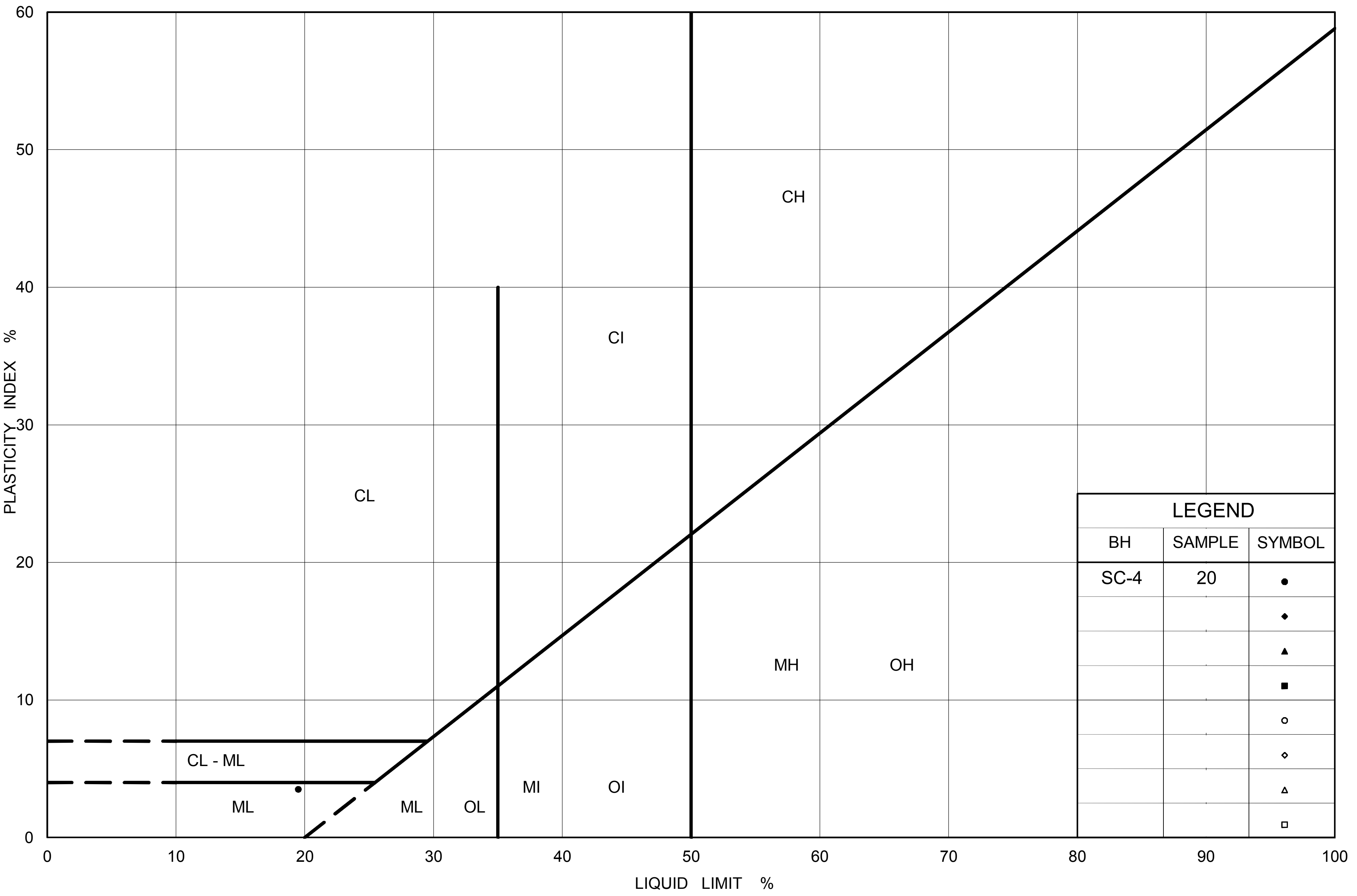
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 08-Feb-13

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Sandy Silt to Silt

Figure No. C12

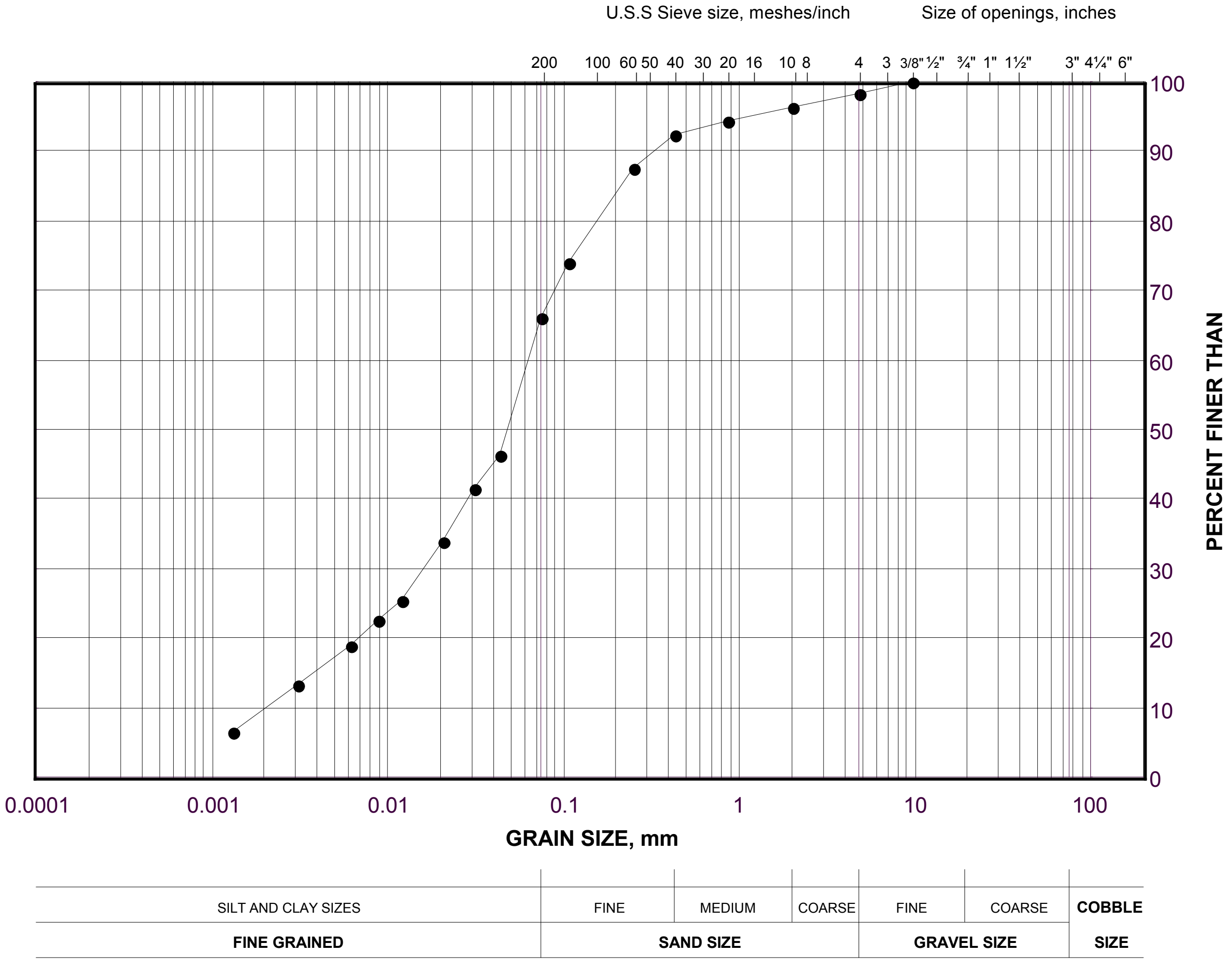
Project No. 09-1111-0018

Checked By: LCC

GRAIN SIZE DISTRIBUTION

Sand and Silt Till

FIGURE C13



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SC-4	15	203.8

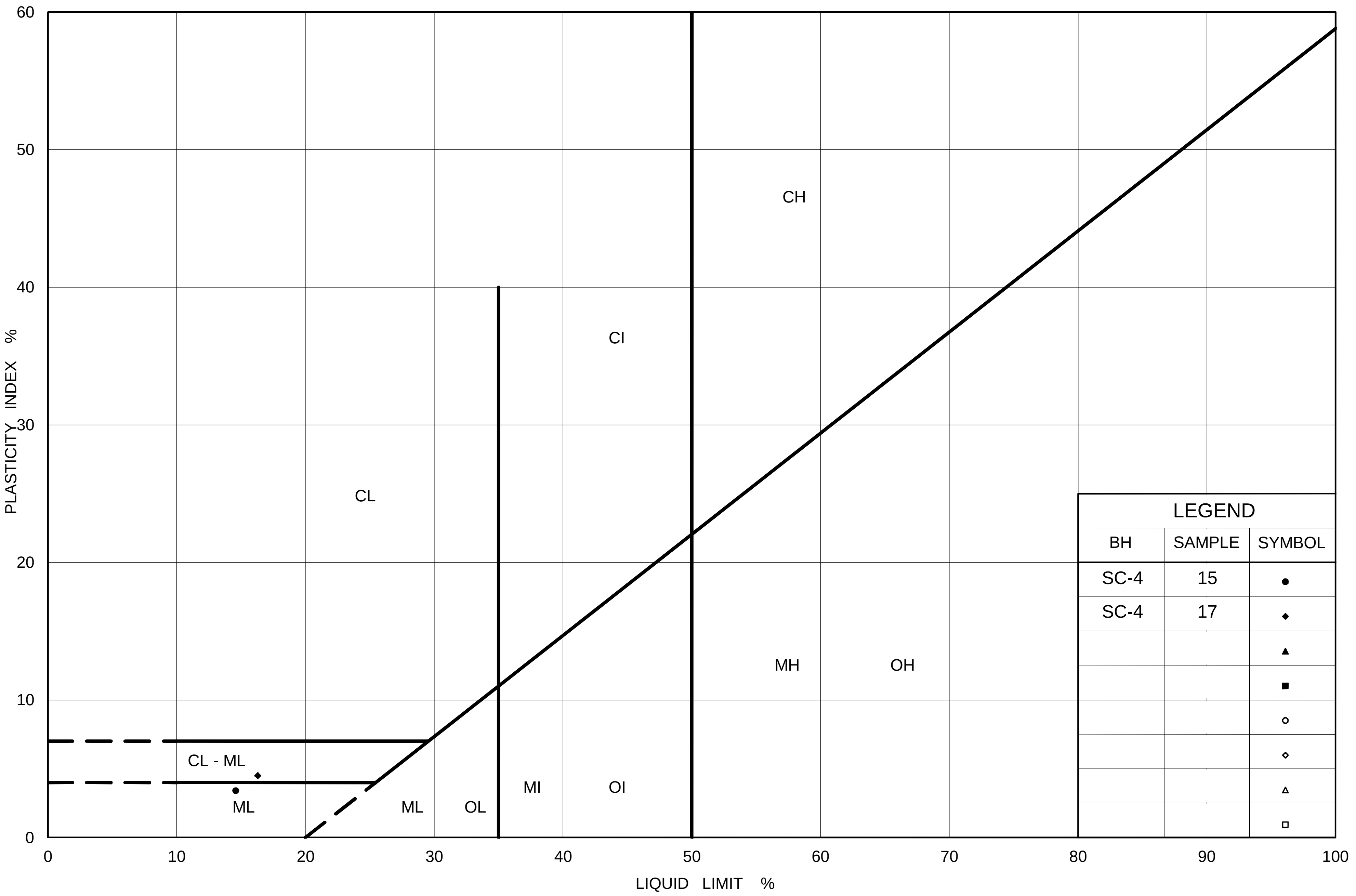
Project Number: 09-1111-0018

Checked By: LCC

Golder Associates

Date: 10-Jul-13

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Sand and Silt (Till)

Figure No. C14

Project No. 09-1111-0018

Checked By: LCC

APPENDIX D

Records of Boreholes and Laboratory Test Results from Previous Report (GEOCRES No. 31D-029)

FORM OB-MT-126 (REV. 1969)

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. BH 29-2

FOUNDATION SECTION

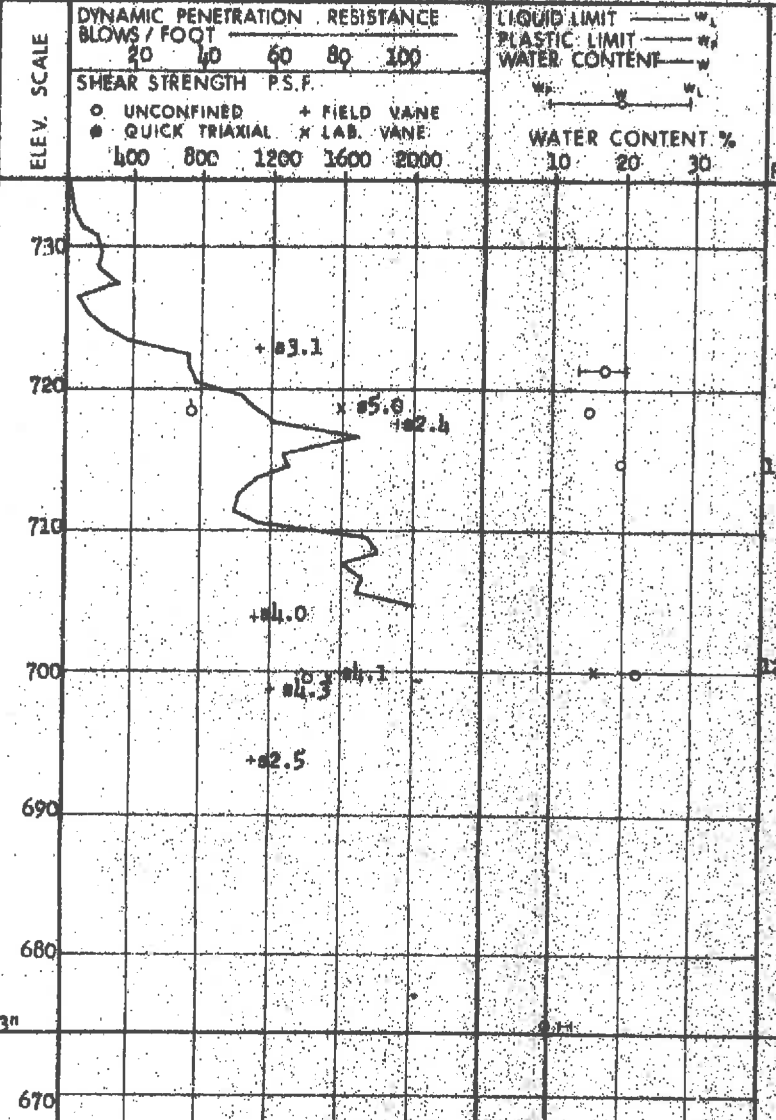
JOB 70-11089
W.P. 105-70-04
DATUM Geodetic
LOCATION Sta. 587 + 07 o/s 54' Lt.
BORING DATE Nov. 13, 1970
BOREHOLE TYPE Washboring-NX Casing
ORIGINATED BY VK
COMPILED BY SAA
CHECKED BY

SOIL PROFILE

(M)	ELEV. DEPTH	DESCRIPTION	STRAT. PLOT
2239	734.7	Ground Level	
2183	0.0 716.2	Clayey silt with trace of sand & gravel (Embankment Fill) Firm to very stiff Brown	
5.6 216.6	18.5 710.7	Silty sand with trace of gravel Compact Grey	
7.3 211.0	24.0 692.2	Clayey silt with trace of sand & gravel Stiff Grey	
13.0 2056	42.5 674.7	Het. mix. of silt, sand & gravel, trace of clay Glacial Till Very Dense Grey	
18.3	60.0	End of Borehole	

SAMPLES

NUMBER	TYPE	BLOWS / FOOT
1	SS	19
2	SS	7
3	TW	PM
4	SS	12
5	TW	PM
6	SS	23
7	TW	PM
8	TW	PM
9	TW	PM
10	TW	PM
11	SS	89
12	SS	85
13	SS	113
14	SS	100/3"



BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL
	729.7 in open BH Nov.17/70 222.2M
133.5	
128.5	

20
15 –○– 5 % STRAIN AT FAILURE
10

FORM OB-MT-126 (REV 1969)

OFFICE REPORT ON SOIL EXPLORATION

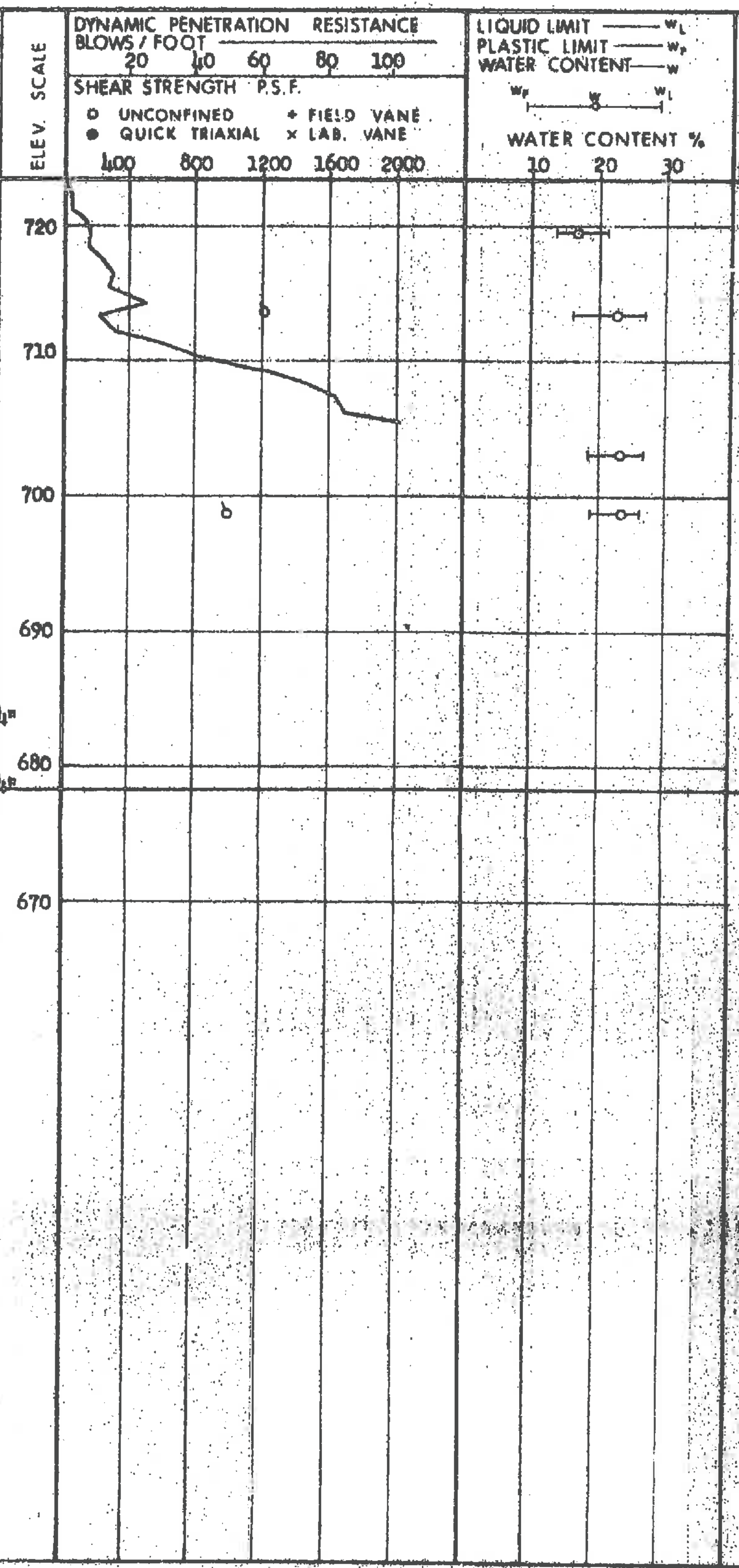
DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 3 BH 29-3

FOUNDATION SECTION

JOB 70-11089
W.P. 105-70-04
DATUM Geodetic
LOCATION Sta. 587 + 87 0/S 59' Rt.
BORING DATE Nov. 10, 1970
BOREHOLE TYPE Washboring and NX Casing
ORIGINATED BY VK
COMPILED BY SAA
CHECKED BY

(m)	ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.	REMARKS GR SA SI CL
220.6	723.6	Ground Level						
	0.0	Clayey silt with trace of sand & gravel.						
				1	SS	11		
		Stiff to Very Stiff						
				2	SS	19		0 10 85 5
218.0	715.1	Brown						
2.6	8.5	Grey		3	TW	PH	132	
				4	SS	28		
				5	SS	25		
				6	SS	25		
				7	TW	PH	129	
				8	SS	12		
210.8	691.6							
9.8	32.0	Het.mix.of silt, sand & gravel, trace of clay.						
				9	SS	85		
		Glacial Till						
				10	SS	100/4"		0 37 53
		Very Dense						
206.7	678.1	Grey		11	SS	100/4"		
13.9	45.5	End of Borehole						



20
15 3 % STRAIN AT FAILURE
10

FORM OB-MT-126 (REV 1969)

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 4 BH29-4

FOUNDATION SECTION

JOB	70-11089	LOCATION	Sta. 588 + 26 o/s 54' Lt.	ORIGINATED BY	VK
W.P.	105-70-64	BORING DATE	Oct. 19/70	COMPILED BY	SAA
DATUM	Geodetic	BOREHOLE TYPE	Cont. Flight Auger	CHECKED BY	

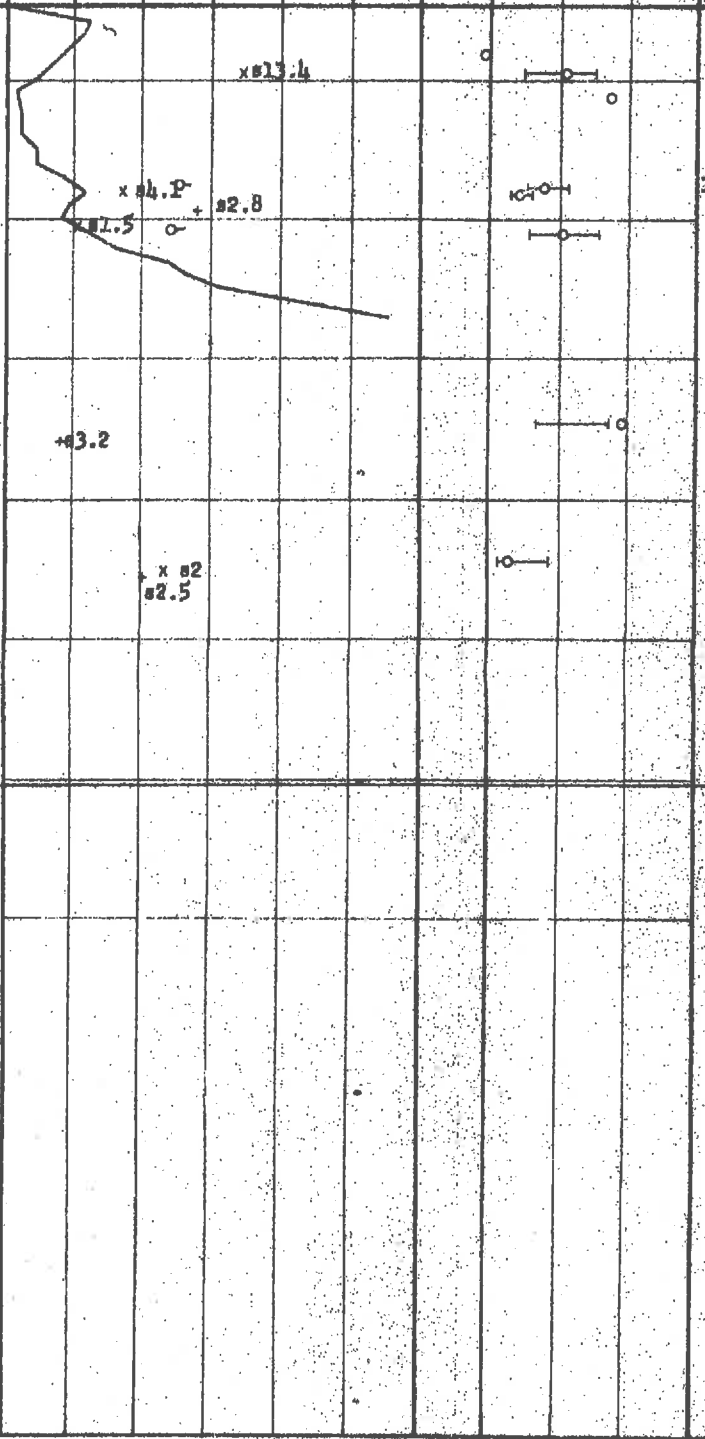
DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT: 20 40 60 80 100

SHEAR STRENGTH P.S.F.: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB. VANE — 400 800 1200 1600 2000

LIQUID LIMIT — w_L; PLASTIC LIMIT — w_P; WATER CONTENT — w

WATER CONTENT %: 10 20 30

	SOIL PROFILE ELEV. DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS / FOOT	ELEV. SCALE	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL
221.1	725.3	Ground Level						
	0.0	Sandy silt, trace of						
219.9	721.3	of ogranics.Loose.Brown						
1.2	4.0		1	SS	6			8 34 46 1 0 6 8 1
			1A	TW	PH	720		
		Clayey silt with trace of sand & gravel and some organics	2	SS	5			Nov. ▼ 2.9% 17/70 Org. 0.8% org.
			2A	TW	PH			
			3	SS	5			
			4	TW	PH		137.5	0 66 (34)
			5	TW	PH	710	130	
		Firm to Very Stiff						
		Grey	6	SS	27			
			7	SS	26	700		
			8	SS	7			
			9	TW	PM	690		
			10	TW	PM		140	
208.0	682.3							
13.1	43.0	Het.mix.of silt,sand & gravel,trace of clay Glacial Till	11	TW	PH	680		
			12	SS	174			6 29 51 14
		Very Dense						
204.2	669.8	Grey	13	SS	147	670		
17.0	55.5	End of Borehole						
						660		



20
15 -○- 5 % STRAIN AT FAILURE
10

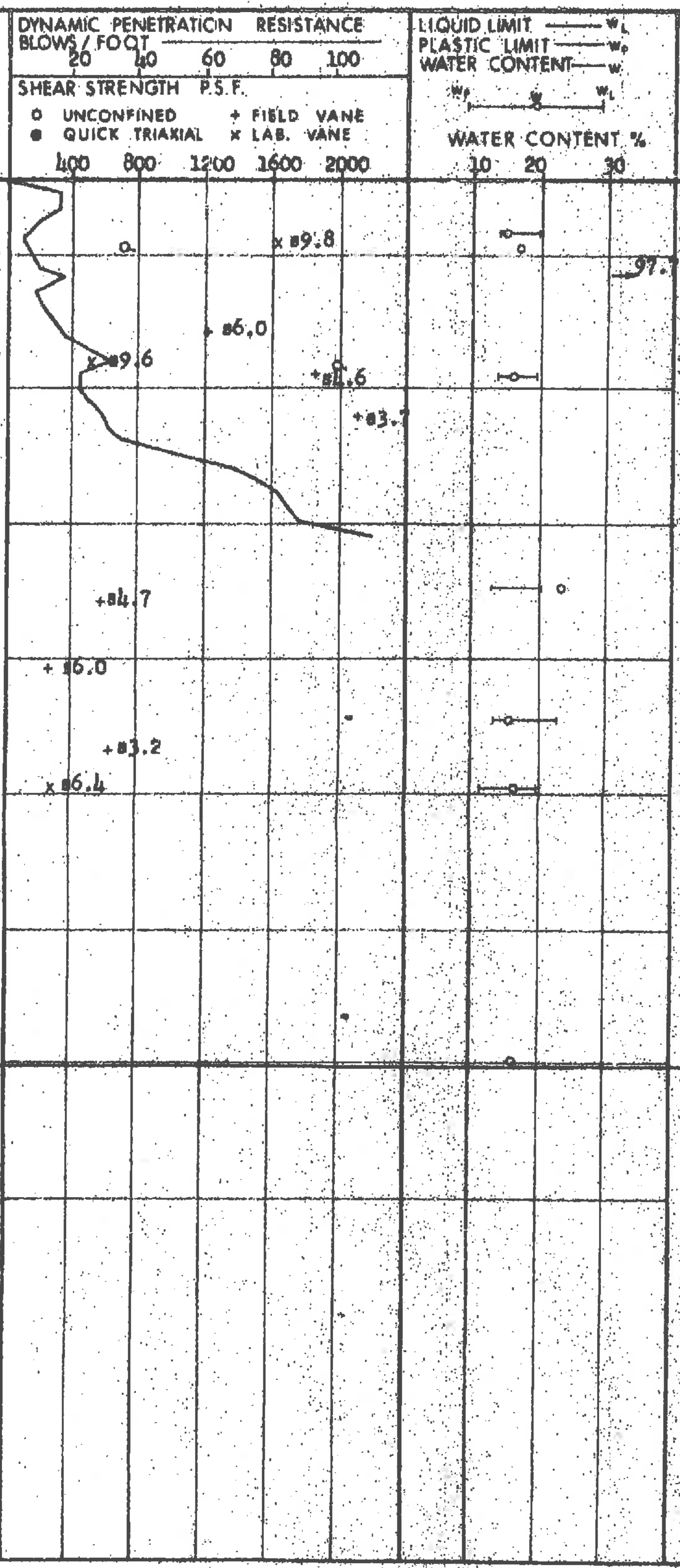
DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5 BH 29-5

FOUNDATION SECTION

JOB 70-11C89
W.P. 105-70-04
DATUM Geodetic
LOCATION Sta. 589 + 08 o/s 57' Rt.
BORING DATE Oct. 20/70
BOREHOLE TYPE Cont. Flight Auger
ORIGINATED BY VK
COMPILED BY SAA
CHECKED BY

(M)	ELEV. DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT	ELEV. SCALE	BULK DENSITY γ P.C.F.	REMARKS GR SA SI Cl
221.1	725.3	Ground Level						
	0.0	Clayey silt with trace of sand & gravel & organics (Fill)	1	SS	4		109	0 25 65 1
219.2	719.3	Firm Brown	1A	TW	PM	720		2.2% Org.
1.8	6.0	Organic Clay	2	SS	4			47.1% Org.
218.3	716.3	Black Soft	2A	TW	PM			
2.7	9.0	Clayey silt with trace of sand & gravel	3	SS	7			
			4	TW	PH	710	138	0 16 77 7
		Soft to Very Stiff	5	SS	7			
		Grey	6	SS	23			
			7	SS	17	700		
			8	TW	PM			
			9	TW	PM	690		No recovery
			10	TW	PM			No recovery
			10A	SS	8			
			11	TW	PH	680		
206.1	676.3							
14.9	49.0	Het.mix.of silt, sand & gravel, trace of clay Glacial Till	12	SS	34			
		Dense to Very Dense	13	SS	77	670		
		Grey	14	SS	159			
201.1	659.8		15	SS	162	660		
20.0	65.5	End of Borehole						
						650		



20
15 5 % STRAIN AT FAILURE
10

FORM OB-MT-126 (REV. 1969)

OFFICE REPORT ON SOIL EXPLORATION

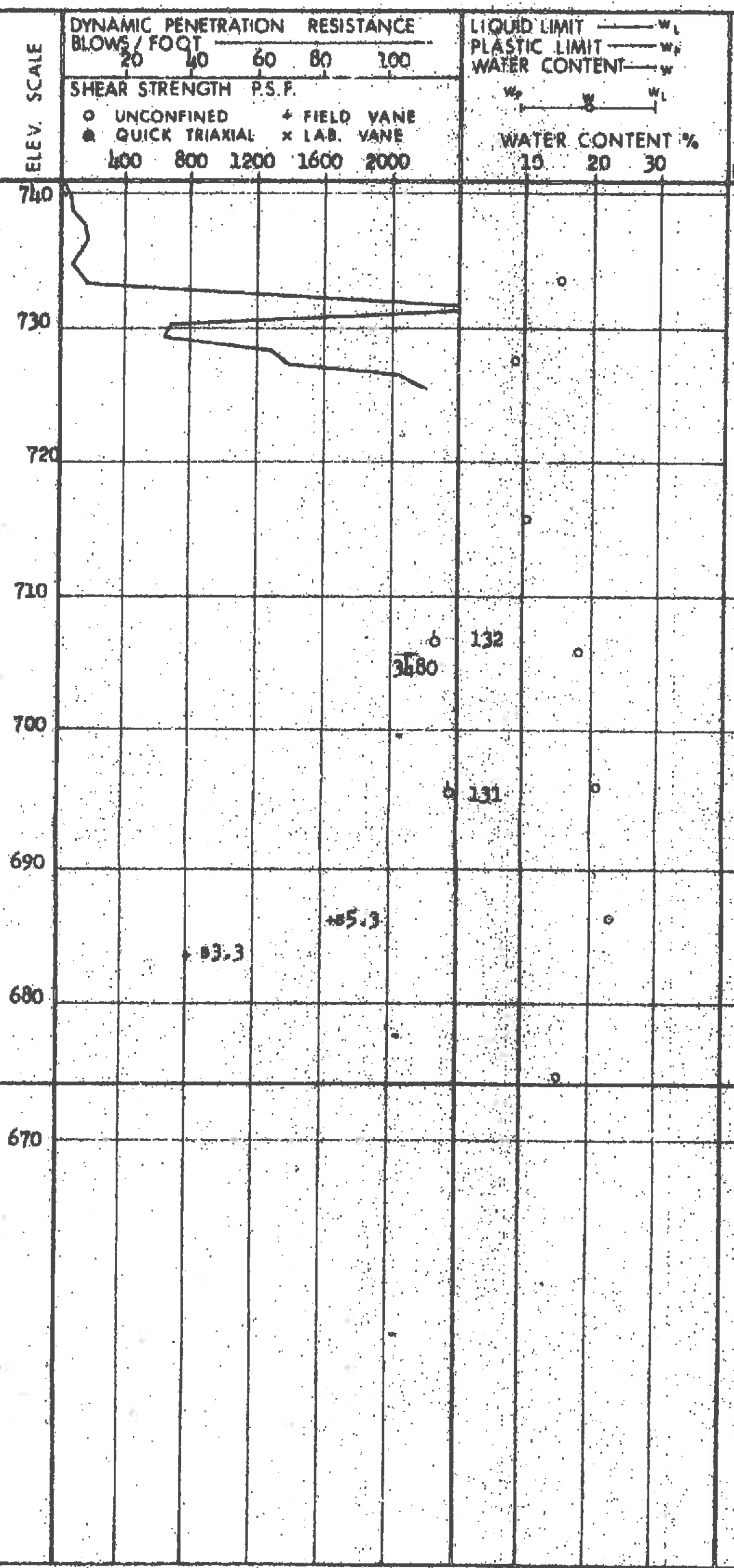
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 6 BH 29-6

FOUNDATION SECTION

JOB 70-11089
W.P. 105-70-04
DATUM Geodetic
LOCATION Sta. 589 + 15 o/s 54.5' Lt.
BORING DATE Nov. 19/70
BOREHOLE TYPE Washboring-NX Casing
ORIGINATED BY VK
COMPILED BY SAA
CHECKED BY

(m)	ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLE NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL
225.8	740.9	Ground Level						
	0.0	Clayey silt, trace of sand & gravel Stiff to Hard Brownish Grey (Embankment Fill)		1	SS	21		
				2	SS	12		
222.5	729.9			3	SS	80		
3.4	11.0	Silty sand, trace of gravel. Very Dense						▼728.9 in open BH Nov.20/70
221.6	726.9			4	SS	66		
4.3	14.0	Clayey silt, trace of sand and gravel Stiff to Hard Brownish grey to grey		5	SS	77		
				6	SS	44		
				7	SS	25		
217.0	711.9	Sandy silt to silt.						
216.5	710.4	Clayey silt		8	SS	13		
9.3	30.5			9	TW	PM	132	
				10	TW	PM		
				11	TW	PM		
				12	TW	PM		
				13	SS	12		
206.9	678.9							
18.9	62.0	Het.mix.of silt,sand & gravel - Glacial Till Very Dense. Grey						
205.6	674.4			14	SS	61		
20.3	66.5	End of Borehole						



20
15 ◆ 5 % STRAIN AT FAILURE
10

FORM 08-MT-126 (REV 1969)

OFFICE REPORT ON SOIL EXPLORATION

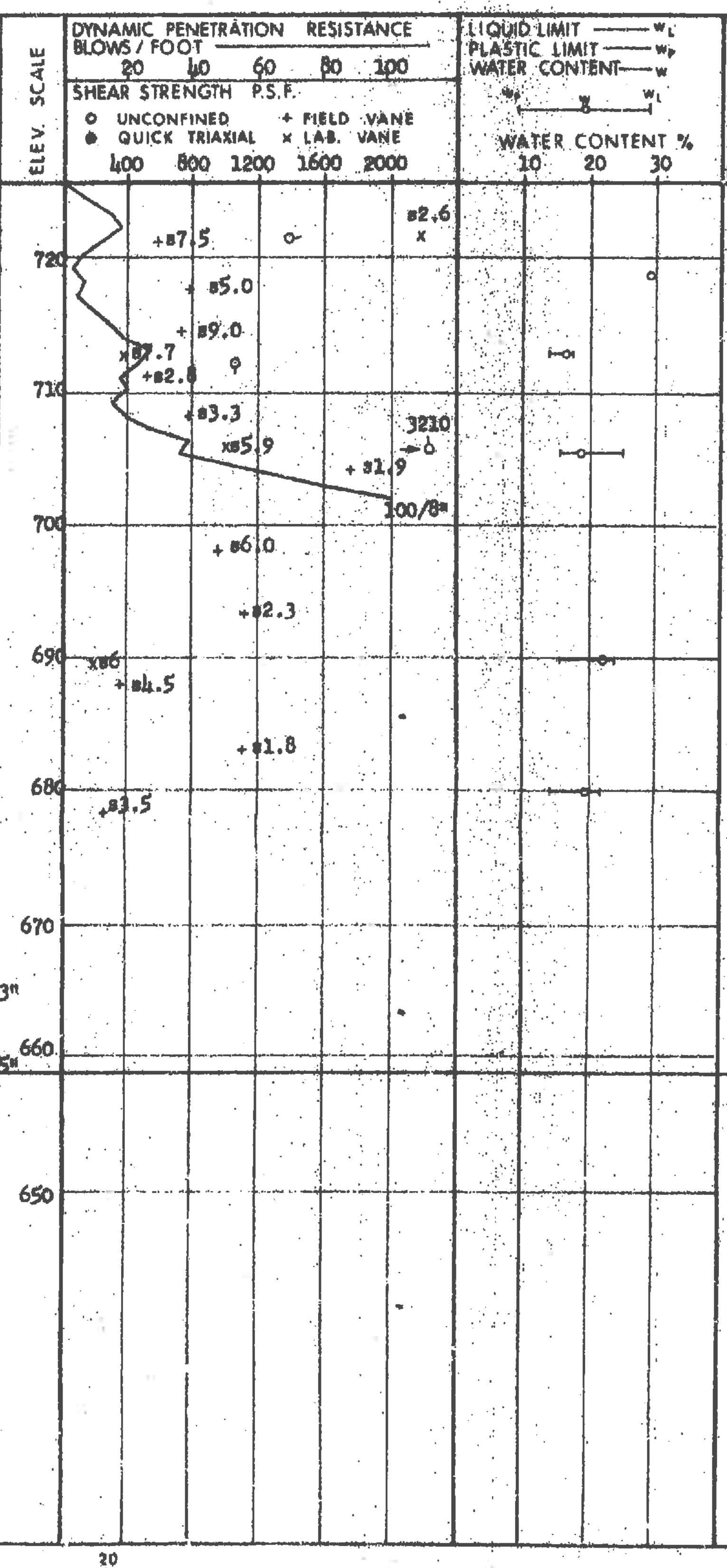
DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 8 BH 29-8

FOUNDATION SECTION

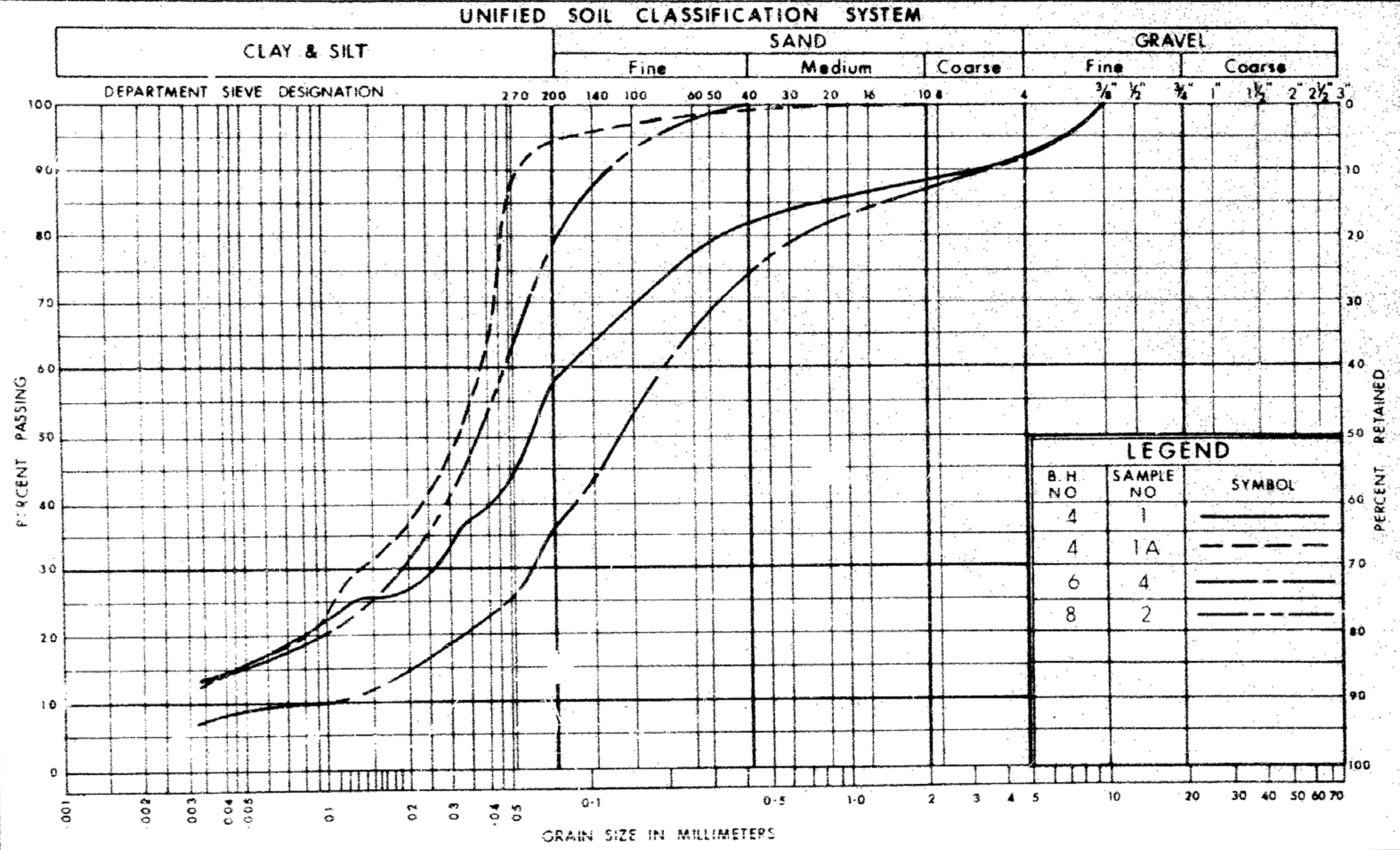
JOB 70-11089
W.P. 105-70-04
DATUM Geodetic
LOCATION Sta. 588 + 46 o/s 2' Lt.
BORING DATE Oct. 21/70
BOREHOLE TYPE Cont. Flight Auger
ORIGINATED BY VK
COMPILED BY SAA
CHECKED BY

(m)	ELEV. DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	BLOWS/FOOT	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL
221.1	725.5	Ground Level					
	0.0	Sandy silt, trace of organics Loose to compact Brown	1	SS	11		Nov.17/70 ▼720.8
			2	SS	7		0 21 69 10
218.4	716.5						
2.7	9.0	Clayey silt with trace of sand & gravel Soft to Stiff Grey	3	SS	8		0 1 87 12
			4	TW	PH	134	
			5	TW	PH		
			6	TW	PH	133	
			7	SS	27		
			8	TW	PH		
			9	TW	PM		
			10	TW	PM		
			11	TW	PM		
206.2	676.5						
14.9	49.0	Het.mix.of silt,sand & gravel, trace of clay - Glacial Till Dense to Very Dense Grey	12	SS	145		
			13	SS	30		
			14	SS	100/3"		
			15	SS	100/5"		
200.9	659.0						
20.3	66.5	End of Borehole					



20
15-⊕-5 % STRAIN AT FAILURE
10

FORM OB MT - 1
REV. APR. 196

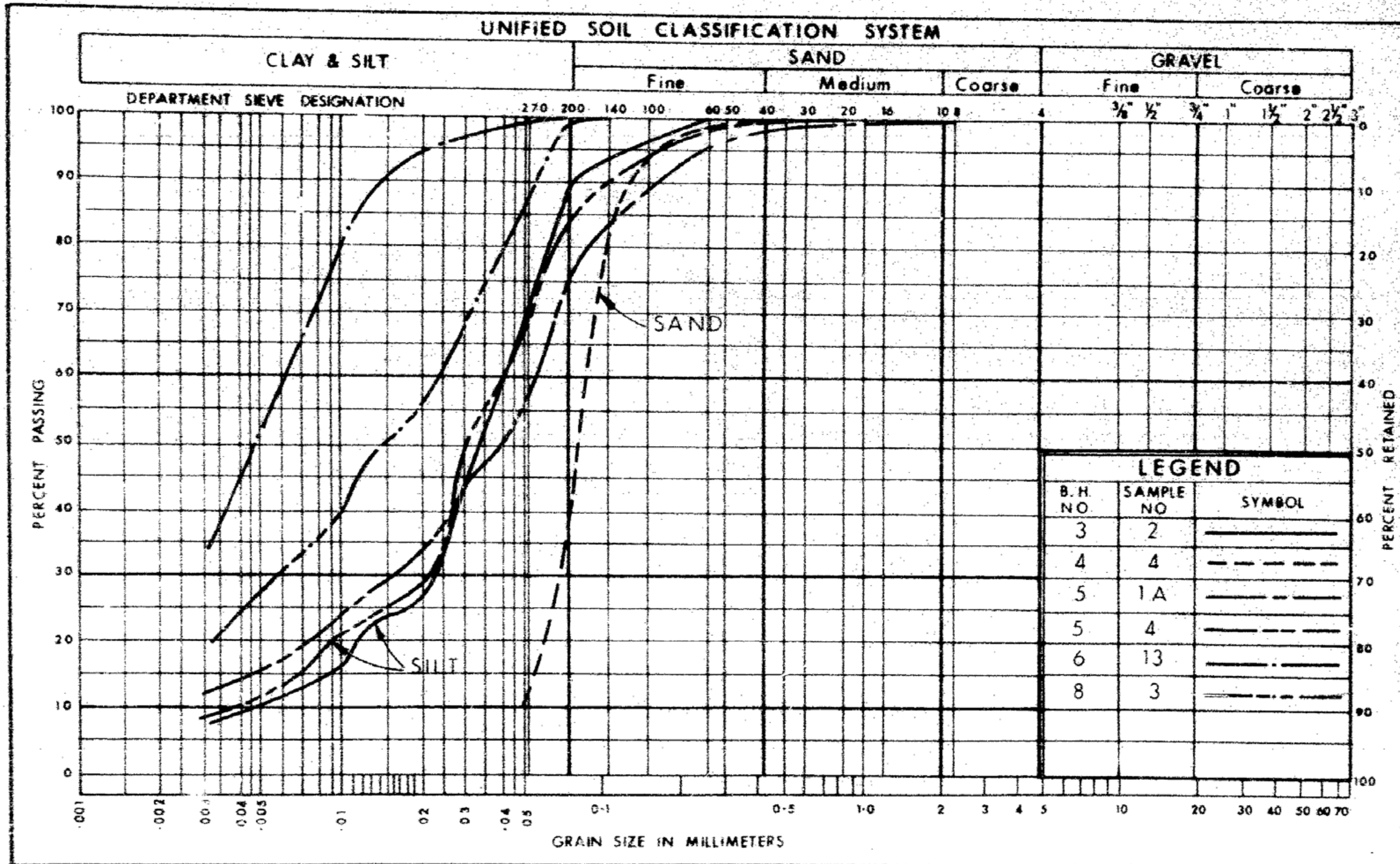


DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND

W.P. No. 105 - 70 - 04
JOB No. 70 - 11089
FIG. 1

FORM OB MT-17
REV. APR. 19

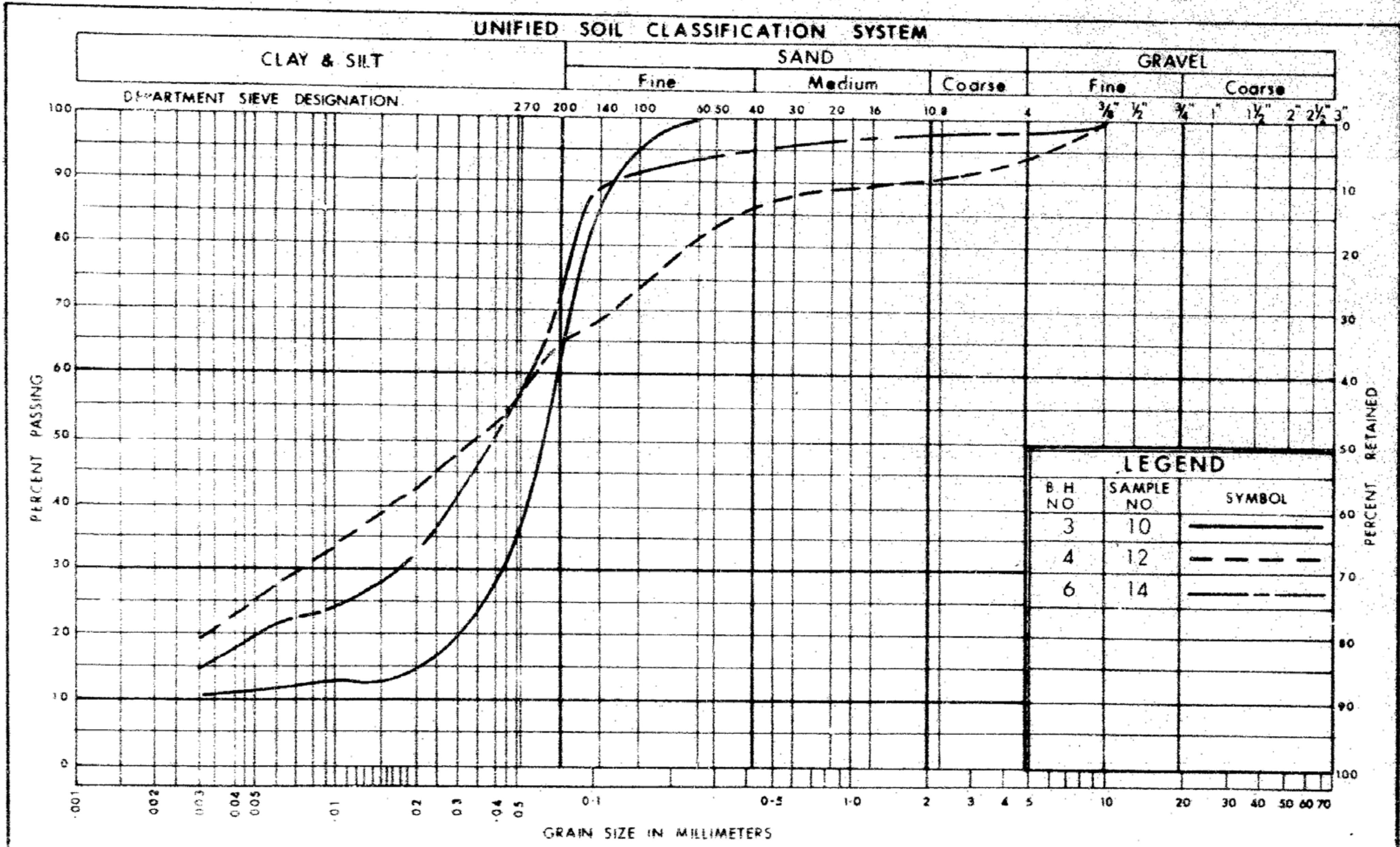


DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

GRAIN SIZE DISTRIBUTION
CLAYEY SILT

W.P. No. 105-70-04
JOB No. 70-11089
FIG. 2

REV. APR. 1965



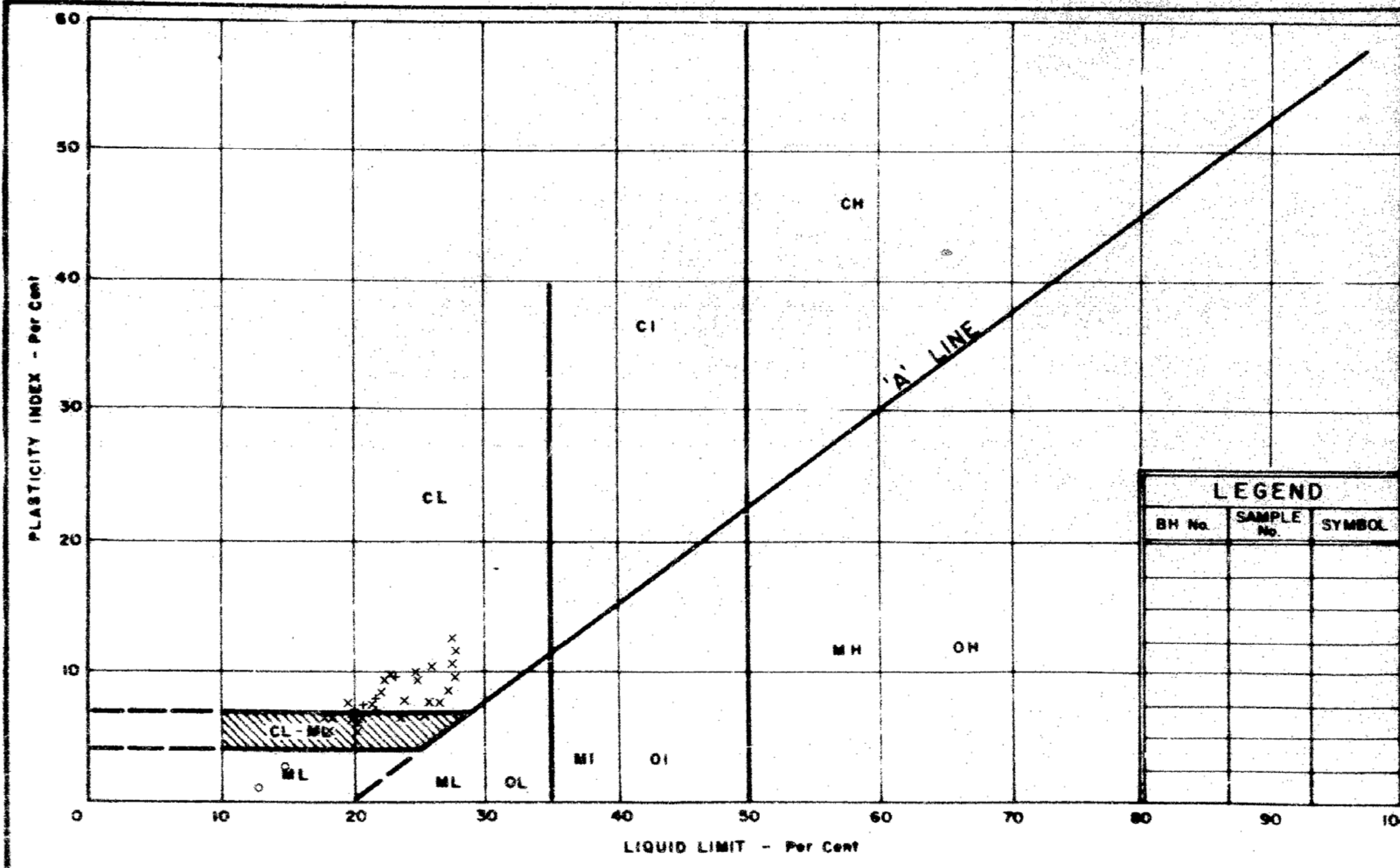
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

GRAIN SIZE DISTRIBUTION
GLACIAL TILL

W.P. No. 105-70-04
JOB No. 70-11089

FIG. 3

FORM OB-MT-252
REVISED JU[illegible] 1966



DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

PLASTICITY CHART

FILL (CLAYEY SILT) — +   CLAYEY SILT STRATUM — ×
GLACIAL TILL — o

W.P. No. 105-70-04
JOB No. 70-11089

FIG. 4

VOID RATIO – PRESSURE CURVES

JOB NO. 70-11089

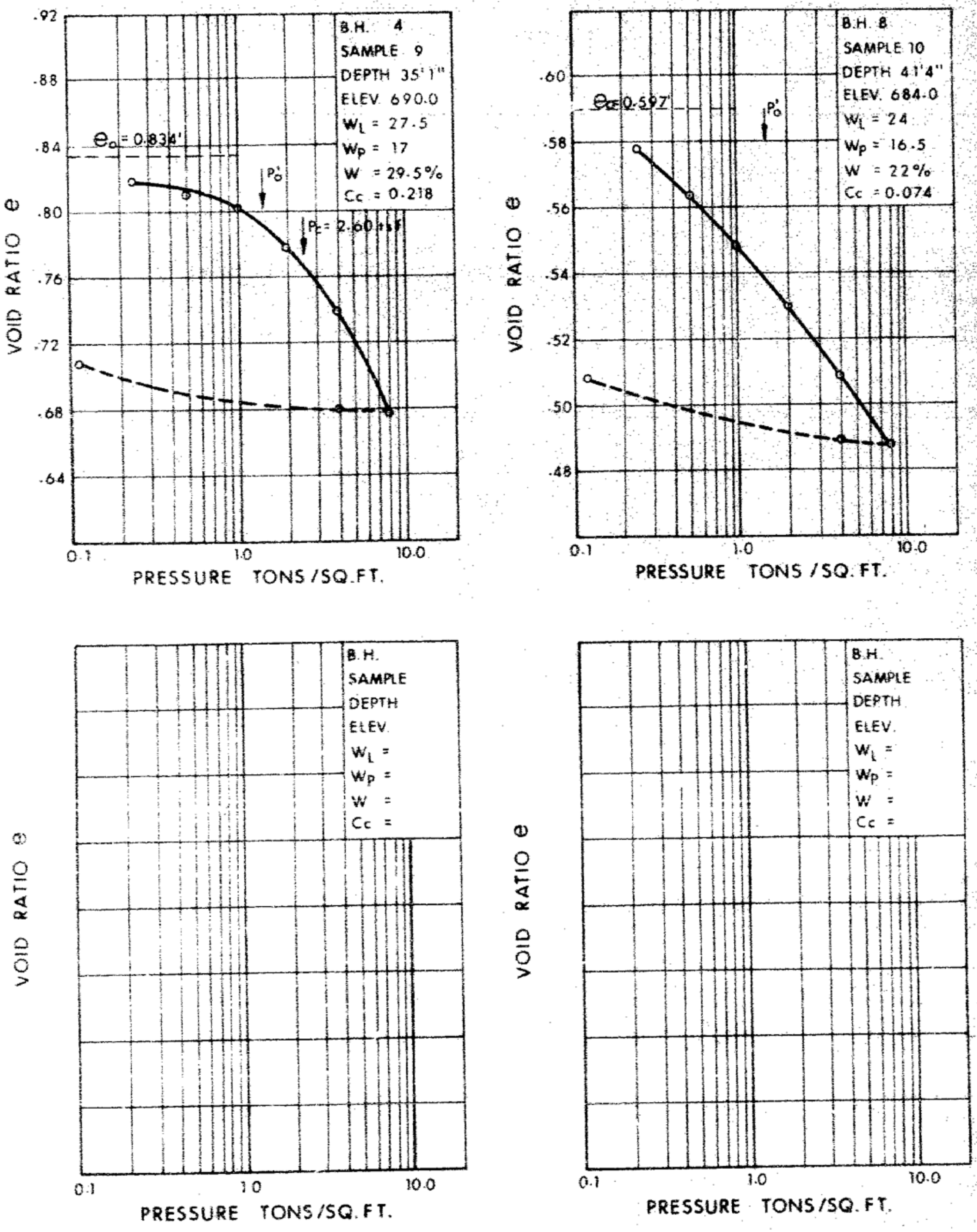


FIG. 5

APPENDIX E

Non-Standard Special Provisions

OPERATIONAL CONSTAINT – Peat/Organic Deposit Excavation

Special Provision

This special provision outlines the procedure to be used for excavation of the peat/organic deposits along the following areas; the depth/elevation of subexcavation in these areas is shown on the Contract Drawings.

- From the north abutment of the South Canal bridges to Station 25+140 on the east side of Highway 400, adjacent to Wist Road.
- From the north abutment of the South Canal bridges to Station 25+110 on the west side of Highway 400, adjacent to Davis Road.

Staged excavation in strips of limited width shall be carried out to maintain the stability of the excavation and protection system along Highway 400, and to protect the existing Wist Road or Davis Road during the subexcavation and backfilling operations. The staged excavations procedures are outlined as follows:

a) The work may be carried out simultaneously from both ends of the area to be subexcavated, working towards the centre.

b) Removal of the peat/organic soils and overlying fill materials within the embankment widening or RSS wall footprint shall be carried out in short "strip" sections perpendicular to the Highway 400 and local road alignments, with the base of the excavation (as measured parallel to Highway 400 and the local road) not wider than 3 m.

c) Temporary excavation side slopes or back slopes through the peat/organic soils and overlying fill materials shall be no steeper than 1 horizontal to 1 vertical (1H:1V) adjacent to the existing local roads (Wist Road or Davis Road).

d) Excavation and backfilling operations shall be carried out simultaneously in a manner that the excavation is not left open for more than the 3 m "strip" width at any given time.

The Contractor shall maintain the operation of the Highway 400, Wist Road and Davis Road during excavation and backfilling operations including and not limited to traffic control.

Payment for the Contractor to provide the above requirements, including all equipment, labour and materials shall be deemed to be included in the contract bid price for the various tender items.

<u>OPERATIONAL CONSTRAINT</u> - Preload Period – Embankment Widening Construction

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Special Provision

The Contractor shall schedule his operation to include the following preloading times for the eastward and westward widening of the embankments on Highway 400 in the vicinity of the South Canal bridges. To allow time for the settlement of the embankment widening and/or two-stage retained soil system (RSS) wall, the following time constraints shall apply:

- For the south approach embankments, extending from the south abutment to 20 m south of that abutment, the embankment widening shall be constructed up to the top of the granular sub-base material, and the fills shall remain in place for a minimum period of six (6) weeks before paving.

- North of the South Canal bridges, extending from the north limit of the EPS behind the north abutment, to Station 25+120, the embankment widening or two-stage RSS wall construction shall be constructed up to the top of the granular sub-base material, and the fills shall remain in place for a minimum period of eight (8) months before paving and before installation of the permanent facing panels on the RSS wall.

- From Station 25+120 to the north limit of the contract, the embankment widening shall be constructed up to the top of the granular sub-base material, and the fills shall remain in place for a minimum period of six (6) months before paving.

Prior to placement of the Granular A base material and paving, the Contractor shall conduct a survey to determine the elevations of the top of the Granular B sub-base material, and shall place additional Granular B Type II material as and where required to achieve the pavement design sub-base elevation.

The Contractor shall not proceed with final granular placement and paving until approval has been given by the Contract Administrator.

LIGHTWEIGHT MATERIAL

Non Standard Special Provision

1.0 SCOPE

This special provision covers the requirements for the supply and placement of lightweight blast furnace slag for the westward widening of the Highway 400 embankment north of the South Canal bridges.

2.0 REFERENCES

ASTM

ASTM D422-63	Standard Test Method for Particle-Size Analysis of Soils
ASTM D2216	Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2850-95	Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test
ASTM D5856-95	Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction Mold Permeameter
ASTM D6938-10	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods

OPSS – Ontario Provincial Standard Specifications

OPSS 102	General Specification for Weighing of Materials
OPSS 206	Construction Specification for Grading

3.0 DEFINITIONS

Quality Verification Engineer: means an Engineer with a minimum of five (5) years experience related to embankment materials and construction, or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and issue of certificate(s)of conformance.

4.0 SUBMISSION AND DESIGN REQUIREMENTS

The Contractor shall submit to the Contract Administrator Certificates of Conformance sealed and signed by the Quality Verification Engineer as follows:

- Prior to the placement of the lightweight fill material on the Contract, the Contractor shall submit to the Contract Administrator a Certificate of Conformance stating that the material satisfies the material properties specified in Table 1. The material properties shall be determined using the test procedures specified in Table 1.

- Following embankment construction, the Contractor shall submit to the Contract Administrator a Certificate of Conformance stating that the material satisfies the requirements of this specification and that the work has been carried out in general conformance with the contract documents and specifications.

In addition, the Contractor shall submit to the Contract Administrator, for information only, all Quality Control Test Results.

5.0 MATERIALS

The Lightweight Blast Furnace Slag shall satisfy the physical, mechanical and chemical property requirements specified in Table 1:

Table 1: Material Properties and Construction Requirements

Property	Requirement	Test Method
Angle of Internal Friction	> 35 °	ASTM D2850-95
Hydraulic Conductivity	> 8 E-03 cm/s	ASTM D5856-95, Method A
Chemical Composition	The material shall meet the Leachate Criteria established under Ontario Regulation 347.	
In-Situ Wet Unit Weight, maximum when placed and compacted in accordance with the requirements of this Special Provision	< 14.5 kN/m^3	ASTM D6938-10

The Contractor shall retain a laboratory that has been inspected and accepted by the MTO under the "Soil and Rock - High Complexity Testing" Specialty to undertake the testing of the material properties. Laboratory testing shall be signed and sealed by an Engineer, licensed to practice in the Province of Ontario

6.0 EQUIPMENT

Compaction equipment technical details are provided in Table 2.

Table 2 – Compaction Equipment Technical Details

	Bomag 142 D	Bomag BPR 30/38 D
Weights		
Operating weight (kg)	4690±	175±
Mass per square metre of base plate (kg/m^2)	N/A	1439
Dimensions		
Drum width (mm)	1426±	N/A
Drum diameter (mm)	1058±	N/A
Width of Base Plate (mm)	N/A	380
Length of Base Plate (mm)	N/A	730
Drive		
Performance DIN 6271 IFN (kW)	37±	3.7
Performance SAE (Kw)	39.5	N/A
Speed (rpm)	2300	3600
Vibratory System		
Frequency (Hz)	32±	68±

Amplitude (mm)	1.24±	N/A
Centrifugal force (Kn)	66±	30±

7.0 CONSTRUCTION

The Contractor is advised that the lightweight blast furnace slag is susceptible to crushing if overcompacted, and that careful construction supervision is required.

The Contractor shall place the lightweight fill material and shall achieve compaction without crushing the material, as crushing increases its unit weight.

The Contractor shall place the lightweight fill material without exceeding the specified in-situ unit weight, and while maintaining crushing of the material below 5%.

To prevent overcrushing and overcompaction, the lightweight fill shall be placed in accordance with OPSS 206.07 with the following amendments:

- For embankments, the lightweight fill shall be placed in lifts of 300 mm and compacted by three (3) passes using single drum vibratory equipment such as a Bomag 142 or equivalent.

- For backfill to structures, the lightweight fill shall be placed in lifts of 300 mm and compacted with eight (8) passes of manually guided tamper such as a Bomag BPR 30/38 D or equivalent.

- The Contractor shall place and spread the loose lifts using a rubber tire front-end loader such as a Caterpillar 980 F or equivalent.

8.0 QUALITY CONTROL

8.1 General

Quality Control (QC) testing shall be carried out by the Contractor for purposes of ensuring that the lightweight fill material is placed and compacted to the requirements specified in the Contract. Field density and field moisture determination shall be made in accordance with ASTM D6938-10.

Acceptability of compaction shall be based on achieving the target in situ unit weight.

8.2 Control Strip

Under the Supervision of the Quality Verification Engineer, the Contractor shall build a control strip to verify that the placement and compaction procedure will achieve the requirements of this Special Provision without evidence of crushing and without exceeding the specified maximum in-situ unit weight of 14.5 kN/m^3.

Prior to incorporating any of the material into the work, the Contractor shall build a minimum trial area of 100 m^2 (approximately 5 m x 20 m) in area consisting of two equal lifts of 300 mm thickness. The Contractor shall give the Contract Administrator written notice of the construction of the control strip 48 hours prior to commencement of this work.

Material placed in the control strip shall have the moisture content that will yield the specified in-situ unit weight. For the control strip determination, the nuclear gauge method will not be considered an acceptable method of determining the in-situ moisture content of the lightweight material. Moisture content shall be determined by the oven dry method on selected compacted embankment material samples in accordance with ASTM D2216.

After the trial area is complete, samples for moisture content and in-situ unit weight determination testing shall be as per ASTM D6938-10.

In addition, gradation as per ASTM D422-63 before and after compaction effort shall be performed to determine that crushing is kept within 5%.

All test results will be used to determine compliance with the specification. Any proposed changes to the specified compaction method shall be reviewed and approved by the Contract Administrator prior to implementation. The requirements of the control strip must be satisfied as part of the acceptance criteria of any proposed change to the specified compaction method of this Special Provision.

9.0 MEASUREMENT OF PAYMENT

The unit measurement will be tonnes and the method of determining the weight of material for payment shall conform to OPSS 102.

10.0 BASIS OF PAYMENT

Payment at the contract price for the above tender item shall be full compensation for all labour equipment and materials required to do the work.

ULTRA LIGHTWEIGHT MATERIAL

Non Standard Special Provision

1.0 SCOPE

This special provision covers the requirements for the supply and placement of ultra-lightweight blast furnace slag for the eastward widening of the Highway 400 embankment north of the South Canal bridges, including the construction of the reinforced soil system (RSS) wall.

2.0 REFERENCES

ASTM

ASTM D422-63	Standard Test Method for Particle-Size Analysis of Soils
ASTM D2216	Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2850-95	Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test
ASTM D5856-95	Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction Mold Permeameter
ASTM D6938-10	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods

OPSS – Ontario Provincial Standard Specifications

OPSS 102	General Specification for Weighing of Materials
OPSS 206	Construction Specification for Grading

3.0 DEFINITIONS

Quality Verification Engineer: means an Engineer with a minimum of five (5) years experience related to embankment materials and construction, or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and issue of certificate(s)of conformance.

4.0 SUBMISSION AND DESIGN REQUIREMENTS

The Contractor shall submit to the Contract Administrator Certificates of Conformance sealed and signed by the Quality Verification Engineer as follows:

- Prior to the placement of the ultra lightweight fill material on the Contract, the Contractor shall submit to the Contract Administrator a Certificate of Conformance stating that the material satisfies the material properties specified in Table 1. The material properties shall be determined using the test procedures specified in Table 1.

- Following embankment construction, the Contractor shall submit to the Contract Administrator a Certificate of Conformance stating that the material satisfies the requirements of this specification and that the work has been carried out in general conformance with the contract documents and specifications.

In addition, the Contractor shall submit to the Contract Administrator, for information only, all Quality Control Test Results.

5.0 MATERIAL

The Ultra-Lightweight Blast Furnace Slag shall satisfy the physical, mechanical and chemical property requirements specified in Table 1:

Table 1: Material Properties and Construction Requirements

Property	Requirement	Test Method
Angle of Internal Friction	> 35 °	ASTM D2850-95
Hydraulic Conductivity	> 8 E-03 cm/s	ASTM D5856-95, Method A
Chemical Composition	The material shall meet the Leachate Criteria established under Ontario Regulation 347.	
In-Situ Wet Unit Weight, maximum when placed and compacted in accordance with the requirements of this Special Provision	< 12.5 kN/m^3	ASTM D6938-10

The Contractor shall retain a laboratory that has been inspected and accepted by the MTO under the "Soil and Rock - High Complexity Testing" Specialty to undertake the testing of the material properties. Laboratory testing shall be signed and sealed by an Engineer, licensed to practice in the Province of Ontario.

6.0 EQUIPMENT

Compaction equipment technical details are provided in Table 2.

Table 2 – Compaction Equipment Technical Details

	Bomag 142 D	Bomag BPR 30/38 D
Weights		
Operating weight (kg)	4690±	175±
Mass per square metre of base plate (kg/m^2)	N/A	1439
Dimensions		
Drum width (mm)	1426±	N/A
Drum diameter (mm)	1058±	N/A
Width of Base Plate (mm)	N/A	380
Length of Base Plate (mm)	N/A	730
Drive		
Performance DIN 6271 IFN (kW)	37±	3.7
Performance SAE (Kw)	39.5	N/A
Speed (rpm)	2300	3600
Vibratory System		
Frequency (Hz)	32±	68±

Amplitude (mm)	1.24±	N/A
Centrifugal force (Kn)	66±	30±

7.0 CONSTRUCTION

The Contractor is advised that the ultra-lightweight blast furnace slag is susceptible to crushing if overcompacted, and that careful construction supervision is required.

The Contractor shall place the ultra-lightweight fill material and shall achieve compaction without crushing the material, as crushing increases its unit weight.

The Contractor shall place the ultra-lightweight fill material without exceeding the specified in-situ unit weight, and while maintaining crushing of the material below 5%.

To prevent overcrushing and overcompaction, the ultra-lightweight fill shall be placed in accordance with OPSS 206-07 with the following amendments:

- For embankments, the ultra-lightweight fill shall be placed in lifts of 300 mm and compacted by three (3) passes using single drum vibratory equipment such as a Bomag 142 or equivalent.
- For backfill to structures, the ultra-lightweight fill shall be placed in lifts of 300 mm and compacted with eight (8) passes of manually guided tamper such as a Bomag BPR 30/38 D or equivalent.
- The Contractor shall place and spread the loose lifts using a rubber tire front-end loader such as a Caterpillar 980 F or equivalent.

8.0 QUALITY CONTROL

8.1 General

Quality Control (QC) testing shall be carried out by the Contractor for purposes of ensuring that the ultra-lightweight fill material is placed and compacted to the requirements specified in the Contract. Field density and field moisture determination shall be made in accordance with ASTM D6938-10.

Acceptability of compaction shall be based on achieving the target in situ unit weight.

8.2 Control Strip

Under the Supervision of the Quality Verification Engineer, the Contractor shall build a control strip to verify that the placement and compaction procedure will achieve the requirements of this Special Provision without evidence of crushing and without exceeding the specified maximum in-situ unit weight of 12.5 kN/m^3.

Prior to incorporating any of the material into the work the Contractor shall build a minimum trial area of 100 m^2 (approximately 5 m x 20 m) in area consisting of two equal lifts of 300 mm thickness. The Contractor shall give the Contract Administrator written notice of the construction of the control strip 48 hours prior to commencement of this work.

Material placed in the control strip shall have the moisture content that will yield the specified in-situ unit weight. For the control strip determination, the nuclear gauge method will not be considered an acceptable method of determining the in-situ moisture content of the ultra lightweight material. Moisture content shall be determined by the oven dry method on selected compacted embankment material samples in accordance with ASTM D2216.

After the trial area is complete, samples for moisture content and in-situ unit weight determination testing shall be as per ASTM D6938-10.

In addition, Gradation as per ASTM D422-63 before and after compaction effort shall be performed to determine that crushing is kept within 5%.

All test results will be used to determine compliance with the specification. Any proposed changes to the specified compaction method shall be reviewed and approved by the Contract Administrator prior to implementation. The requirements of the control strip must be satisfied as part of the acceptance criteria of any proposed change to the specified compaction method of this Special Provision.

9.0 MEASUREMENT OF PAYMENT

The unit measurement will be tonnes and the method of determining the weight of material for payment shall conform to OPSS 102.

10.0 BASIS OF PAYMENT

Payment at the contract price for the above tender item shall be full compensation for all labour equipment and materials required to do the work.

RETAINED SOIL SYSTEM, TRUE ABUTMENT - Item No.
RETAINED SOIL SYSTEM, FALSE ABUTMENT - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, HIGH PERFORMANCE - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, MEDIUM PERFORMANCE - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, LOW PERFORMANCE - Item No.
RETAINED SOIL SYSTEM WITH FINISHING CAP, WALL/SLOPE, HIGH PERFORMANCE - Item No.
RETAINED SOIL SYSTEM WITH FINISHING CAP, WALL/SLOPE, MEDIUM PERFORMANCE - Item No.
RETAINED SOIL SYSTEM WITH TRAFFIC BARRIER, WALL/SLOPE, HIGH PERFORMANCE - Item No.
RETAINED SOIL SYSTEM WITH TRAFFIC BARRIER, WALL/SLOPE, MEDIUM PERFORMANCE - Item No.
RETAINED SOIL SYSTEM, ROADBASE EMBANKMENT - Item No.

Special Provision No. 599S22

1.0 SCOPE

This special provision covers the requirements for the design, supply and construction of Retained Soil Systems (RSS).

Special requirements apply for the design of the steel reinforcing strips where lightweight or ultra-lightweight slag fill is used as backfill to the RSS wall(s), at the locations specified elsewhere in the Contract Documents. The galvanized steel reinforcing strips shall be designed to be thicker (i.e., to have a sacrificial thickness) to mitigate the potential for corrosion in the slag fill environment.

Additional requirements for RSS precast concrete facing elements shall be as specified elsewhere in the Contract.

2.0 REFERENCES

This special provision refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, General:

OPSS 180	Management and Disposal of Excess Materials

Ontario Provincial Standard Specifications, Construction:

OPSS 501	Compaction
OPSS 539	Protection Schemes

Ministry of Transportation Publications

MTO Designated Sources of Materials (DSM)
Generic Requirements for Retained Soil Systems for DSM
Ontario Highway Bridge Design Code 1991 - 3rd Edition (OHBDC)

3.0 DEFINITIONS

For the purposes of this special provision the following definitions apply:

Approved Product Drawings: means the documentation for an RSS which has been submitted to the Ministry by the Manufacturer for approval and listing in the DSM, in accordance with the Generic Requirements for Retained Soil Systems for DSM.

Associated Backfill: means all backfill other than engineered backfill necessary to construct the RSS, and to reinstate the excavation for the RSS.

Design Engineer: means the Engineer who produces the working drawings; the Design Engineer shall be certified by the Manufacturer as having the appropriate experience and expertise to provide design services for the Manufacturer’s RSS.

Design Check Engineer: means the Engineer who checks the original design; the Design Check Engineer shall be certified by the Manufacturer as having the appropriate experience and expertise to provide design services for the Manufacturer’s RSS.

Engineered Backfill: means all backfill that is part of the engineered materials comprising the RSS and/or the RSS foundation.

External Stability: means the stability of the foundation and slope/embankment on which the RSS relies for support during and after construction.

Internal Stability: means the stability of the engineered materials comprising the RSS.

Manufacturer: means the party who supplies and/or specifies the design, materials and components for the RSS selected by the Contractor.

Quality Verification Engineer: means an Engineer recognized by the Manufacturer as having demonstrated experience and expertise to provide quality verification services for the Manufacturer's RSS. The Quality Verification Engineer shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and to issue Certificates of Conformance.

Retained Soil System (RSS): means a proprietary system which uses mechanical soil stabilization to retain horizontal loads in excess of 2 m in height for applications such as true and false abutment structures, retaining walls and steep slopes; or, to retain vertical loads for applications such as embankments over soft ground.

Stamped: means working drawings that have been reviewed and stamped “Conforms with Contract Documents”. The stamp shall include the date and signature of the Quality Verification Engineer

4.0 SUBMISSION AND DESIGN REQUIREMENTS

4.1 Submissions

4.1.1 Working Drawings

All submissions shall bear the seal and signature of the Design Engineer and the Design Check Engineer.

The Contractor shall submit working drawings for the design, fabrication and construction of the RSS to the QVE for review and stamping.

The Contractor shall have a copy of the stamped working drawings on site at all times.

At least two weeks prior to commencement of construction of the RSS, the Contractor shall submit to the Contract Administrator three (3) sets of the stamped working drawings. The Contract Administrator will forward one set of the stamped working drawings to the Pavement and Foundation Section, Ministry of Transportation, Downsview, for information purposes.

4.1.2 Working Drawing Requirements

Working drawings shall include at least the following:

- All design, fabrication and construction drawings and specifications for the RSS, including details regarding the thickness of the galvanized steel reinforcing strips where slag fill is used;
- Details of all excavation, unwatering, drainage and backfilling required to construct the RSS, including type and source of associated backfill;
- Details at joints and connections to other structures where shown in the Contract Drawings
- Details of all protection systems;
- Statement of bearing resistance required by the RSS foundation, and the bearing resistance provided in accordance with the OHBDC;
- Statement of satisfactory internal and external stability;
- All design, fabrication and construction drawings and specifications for traffic barriers and base, and finishing caps, where applicable;
- Details of how all relevant Operational Constraints and Environmental Constraints, as specified elsewhere in the Contract, will be adhered to.
- A copy of the Approved Product Drawings covering material and construction details

4.1.3 Certificate of Conformance

The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer upon completion of each of the following operations and prior to commencement of each subsequent operation:

- Foundation base preparation
- On-site delivery of manufactured and fabricated components
- Alignment of RSS as per contract documents
- Backfill material

The Certificates of Conformance shall state that the materials and work have been supplied and installed in general conformance with the stamped working drawings and Contract documents.

Upon completion of the RSS installation, the Contractor shall submit to the Contract Administrator a final Certificate of Conformance sealed and signed by the Quality Verification Engineer stating that the RSS has been constructed in general conformance with the stamped working drawings and Contract documents.

4.1.4 Warranty

The Contractor shall submit an unconditional warranty to the Owner, to implement all repair and maintenance requirements to the RSS related to design, materials and workmanship for a period of three (3) years from the date of certification of completion of the Contract.

4.2 Design

4.2.1 General

The Contractor shall verify the existing site conditions and ground elevations before preparing the working drawings, and notify the Contract Administrator immediately if site conditions differ from those described in the Contract.

The Application, Performance, and Appearance requirements for the RSS shall be as specified elsewhere in the Contract.

The geometric requirements of the RSS, including alignment and profiles, typical cross-sections, and location of traffic barriers and/or finishing caps, as well as other constraints influencing the design of the RSS, shall be as specified elsewhere in the Contract.

4.2.2 RSS Selection

The Contractor may select any RSS designated as A (Accepted) or as DE (Demonstration) on the DSM List that meets the specified Contract requirements. RSS qualified as DE (Demonstration) status will require inspection, instrumentation, monitoring and reporting by the Manufacturer, in accordance with the Generic Requirements for Retained Soil Systems for DSM.

The RSS selected and designed by the Contractor shall meet all of the requirements for the RSS specified in the Contract.

4.2.3 Design of Steel Reinforcing Strips for Use With Slag Fill

Where lightweight or ultra-lightweight slag fill is to be used as backfill to the RSS, the galvanized steel reinforcing strips will be subjected to higher corrosion rates as compared to sand and gravel backfill. For this application, the galvanized steel reinforcing strips shall be designed and supplied with sufficient thickness for a 75-year design life, based on the following properties for the slag fill:

Electro-Chemical Parameter	Criterion	Test Method
Chlorides	<200 ppm	D4327
Total Sulphates	<1,000 ppm	D2492
Resistivity	>1,000 ohm-cm	G187
pH	5-10	D4972

4.2.4 Foundation Investigation Report

A Foundation Investigation Report that describes the subsurface conditions at the RSS is available, as specified elsewhere in the Contract. The Owner warrants that the information provided in the Foundation Investigation Report can be relied upon with the following limitations and exceptions:

Any interpretations of data or opinions expressed in the report are not warranted; and

Although the raw measured data presented is warranted, the Contractor must satisfy himself as to sufficiency of the information presented and obtain any updating or additional information, and perform any studies, analyses or investigations the Contractor deems necessary in order to prepare his design, at no additional cost to the Owner.

4.2.5 Protection Systems

Where the stability, safety or function of an existing roadway, railway, and other works can be impaired by an excavation or temporary slope, the Contractor shall provide protection systems as required, including sheet-piling, shoring, and the driving of piles where necessary, to prevent damage to such works.

Design of protection systems shall be in accordance with SP 539S01.

5.0 MATERIALS

5.1 General

All materials for the selected RSS shall conform to Approved Product Drawings for that RSS.

5.2 Steel Reinforcing Strips for Use with Slag Fill

Where lightweight or ultra-lightweight slag fill is used as backfill for the RSS, the galvanized steel reinforcing strips shall have sufficient thickness for a 75-year design life.

5.3 Associated Backfill

Associated backfill shall be suitable for the particular application, and be approved by the Design Engineer as compatible with the RSS.

7.0 CONSTRUCTION

7.1 General

The work shall include the construction of the RSS, with traffic barriers and finishing caps where specified, and all excavation, unwatering, drainage and backfilling required to construct the RSS.

Associated backfill shall be compacted in accordance with OPSS 501.

7.2 RSS

The RSS shall be constructed in conformance with the stamped working drawings.

7.3 Protection Systems

Protection systems shall be constructed in accordance with the stamped working drawings.

Protection systems shall be removed in accordance with SP 539S01.

7.4 Management of Excess Materials

Excess materials resulting from carrying out the work shall be removed and managed as specified elsewhere in the Contract.

8.0 QUALITY ASSURANCE

The Contractor shall submit representative samples of the RSS components to the Contract Administrator when requested.

10.0 BASIS OF PAYMENT

Payment at the contract price for the above tender item(s) shall be full compensation for all labour, equipment and material to do the work.

NOTES TO DESIGNER:

Include SP 599S23 for Precast Concrete Facing Elements
Include SP 539S01 for Protection Systems

WARRANT: Always with these tender items.

APPENDIX F

Settlement Monitoring Plan

SETTLEMENT PLATES – Item No.
SETTLEMENT PINS – Item No.
SETTLEMENT PROFILERS – Item No.
SHAPE ACCEL ARRAYS – Item No.

Special Provision

1.0 GENERAL

The Contractor shall retain a Foundation Engineering consultant registered in MTO's Consultant Registry, Appraisal and Qualifications System (RAQS) for "Geotechnical Specialty – High Complexity", to undertake the supply and installation of geotechnical monitoring instrumentation.

"The Contractor" shall be understood to refer to the Contractor and their Foundation Engineering consultant.

1.1 Scope

This special provision and the other item-specific special provisions contain the requirements for the supply and installation of the following geotechnical monitoring instrumentation:

- Settlement Plates (SP);
- Settlement Pins (S);
- Vibrating Wire Piezometers (VWP);
- Standpipe Piezometers (SSP);
- Settlement Profilers (PR);
- Inclinometers (INC); and
- Shape Accel Arrays (SAA).

This special provision also contains the requirements for the supply and installation of temporary survey Benchmarks (BM).

1.2 Purpose

The purpose of these instruments is to monitor the progress of settlement, lateral displacement and dissipation of excess porewater pressure in the foundation soils under the embankment widening and two-stage retained soil system (RSS) wall construction in the Holland Marsh area. The purpose of the survey Benchmarks is to provide non-settling references for the surveying of the monitoring instruments.

The rate and staging of fill placement and the duration of the preloading period prior to paving and opening to traffic, and prior to installation of the permanent facing panels for the two-stage RSS wall, will be controlled by the instrumentation readings, as specified elsewhere in the Contract Documents. The completed, preloaded embankment and RSS wall area shall remain undisturbed until such time as the monitoring shall indicate that a sufficient degree of consolidation of the foundation soil has been achieved. Pavement construction and installation of the permanent facing panels for the two-stage RSS wall shall not take place until sufficient consolidation has been achieved as determined by the Contract Administrator.

1.3 Or Equal

The term “or equal” shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration.

1.4 Notification

The Contract Administrator shall be notified a minimum of 15 working days in advance of commencing the installation of instruments.

1.5 Submission Requirements

The Contractor shall submit details of the proposed installation methods including locations and types of the data acquisition system, monitoring enclosure, survey benchmarks and installation schedule, to the Contract Administrator, a minimum of 15 working days before the start of instrument installation.

2.0 SITE CONDITIONS

2.1 Subsurface Conditions

The subsurface conditions at the site are described in the following report:

- Foundation Investigation Report – Embankment Widening and RSS Wall Construction, Highway 400 Widening from North of King Road to North of South Canal Bridges, Regional Municipality of York, GWP 2025-13-00”, by Golder Associates Ltd., dated January 14, 2015.

2.2 Equipment Operation and Weather Conditions

All monitoring equipment and associated materials shall be capable of withstanding the range of temperatures possible for their location within the ground or on the surface. The instruments shall be capable of operating within the manufacturer’s stated accuracy throughout the temperature range. Monitoring will be conducted year-round by the Contract Administrator.

3.0 MONITORING INSTRUMENT INSTALLATIONS

3.1 Drawings

Reference shall be made to the following drawings that are contained elsewhere in the Contract Documents:

- Monitoring Instrumentation Plans; and
- Typical Instrument Installation Details.

3.2 Quantities and Locations of Instruments

The quantities and location of instruments are presented in Table 1A and are shown on the Contract Drawings.

Table 1A – Instrument Quantities and Locations

Monitoring Section	Approx. Station	Quantities						
		SP	S	VWP	SSP	PR	INC	SAA
Hwy 400 NBL Sta 24+800 to 24+830	24+805	1	1	-	-	-	-	-
	24+825	1	1	-	-	-	-	-

Monitoring Section	**Approx. Station**	**Quantities**						
		SP	**S**	**VWP**	**SSP**	**PR**	**INC**	**SAA**
Hwy 400 SBL Sta 24+770 to 24+790	24+770	1	1	-	-	-	-	-
	24+790	1	1	-	-	-	-	-
Hwy 400 NBL Sta 24+920 to 25+140	24+925	1	1	1	1	1	1	1
	24+975	1	1	1	-	-	-	-
	25+025	1	1	1	-	1	1	1
	25+075	1	1	1	-	-	-	-
	25+125	1	1	1	-	-	-	-
Hwy 400 NBL Sta 25+140 to 25+750	25+200	1	1	-	-	-	-	-
	25+275	1	1	-	-	-	-	-
	25+350	1	1	-	-	-	-	-
	25+425	1	1	-	-	-	-	-
	25+500	1	1	-	-	-	-	-
	25+575	1	1	-	-	-	-	-
	25+650	1	1	-	-	-	-	-
	25+725	1	1	-	-	-	-	-
Hwy 400 SBL Sta 24+880 to 25+200	24+890	1	1	1	1	1	-	1
	24+940	1	1	1	-	1	-	1
	24+990	1	1	-	-	-	-	-
	25+040	1	1	-	-	-	-	-
	25+115	1	1	-	-	-	-	-
	25+190	1	1	-	-	-	-	-
TOTALS:		**23**	**23**	**7**	**2**	**4**	**2**	**4**

3.3 Materials and Equipment

The Contractor shall supply all materials and equipment required for the installation of instrumentation unless otherwise noted.

3.4 Instrument Location

Prior to the installation of instruments, the Contractor shall accurately survey and stake the location of each instrument and obtain a ground elevation at each instrument location.

3.5 Underground Utilities

The Contractor shall be responsible for locating and protecting all underground utilities prior to drilling boreholes for installing instruments. Any damage to underground utilities caused by the Contractor’s work shall be repaired by the Contractor at no cost to the Owner or Contract Administrator.

3.6 Marking and Labelling

The location of any above-ground monitoring fixture shall be made clearly visible to nearby traffic before, during and after embankment/RSS wall construction. Marking shall be of sufficient size to be visible from a reversing vehicle and after heavy snow falls.

Instruments and their data cables shall be clearly labelled in the field, with each instrument having a unique identifier. The labelling shall remain legible for the entire duration of monitoring.

3.7 Protection of Instruments

The Contractor shall adequately protect all instruments such that they are not damaged during construction. Any instrument damaged by the Contractor’s work shall be immediately replaced by the Contractor at no cost to the Owner or Contract Administrator.

3.8 Survey Personnel

Surveying to establish the benchmarks and other elevations shall be carried out by a registered surveyor with appropriate equipment. The surveyor shall be retained by the Contractor.

3.9 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of ± 2 mm or better.

3.10 Boreholes

The Contractor shall make a basic stratigraphic log of boreholes as they are being drilled for the installation of monitoring instruments. In situ or laboratory geotechnical testing is not required.

Boreholes shall be advanced using conventional drilling methods and shall be as straight and vertical as practicable.

3.11 Installation Program

Instrument installation shall commence immediately after completion of subexcavation as specified elsewhere in the Contract Documents, and prior to the commencement of the embankment or RSS wall construction. Table 1B gives a summary of the installation schedule requirements.

Table 1B – Instrument Installation Program

Instrument Type	Start Installation	Finish Installation
SP	After subexcavation, and before start of embankment/RSS wall construction	Extended as fill placement proceeds, to completion of embankment/RSS wall to preload grade
NP	At completion of embankment/RSS wall construction to preload grade	At completion of embankment/RSS wall construction to preload grade
VWP	After subexcavation, and before start of embankment/RSS wall construction	Adjust as fill placement proceeds, to completion of embankment/RSS wall to preload grade
SSP	Before start of embankment/RSS wall construction	Before start of embankment/RSS wall construction
PR	After subexcavation, and before start of embankment/RSS wall construction	Extended as fill placement proceeds, to completion of embankment/RSS wall to preload grade
INC	After subexcavation, and before start of embankment/RSS wall construction	Before start of embankment/RSS wall construction

Instrument Type	Start Installation	Finish Installation
SAA	After subexcavation, and before start of embankment/RSS wall construction	Before start of embankment/RSS wall construction

4.0 BENCHMARK INSTALLATION

4.1 Number and Locations

The minimum number and approximate locations of the Benchmarks are shown on the Contract Drawings and in Table 2. The number and locations of Benchmarks shall be adjusted in the field such that:

- Direct sighting is possible from all instruments to at least one Benchmark;
- Each Benchmarks is located in an area that will not experience a change in loading (due to grade raise or excavation) that could induce settlement or heave in the ground in which the Benchmark is installed; and
- Each Benchmark is located in such a way to minimize interference with and damage by construction activities.

Table 2 – Survey Benchmark (BM) Locations

Monitoring Area	Approx. Station	Approx. Offset from CL (m)	Approx. Elevation of Bottom of Anchor (m)*	Approx. Length of Rod Incl. Stick-Up (m)*
Hwy 400 NBL Sta 24+800 to 24+830	24+850	60 m east	208	13
Hwy 400 SBL Sta 24+770 to 24+790	24+775	75 m west	208	13
Hwy 400 NBL Sta 24+920 to 25+140	25+050	East shoulder of Wist Road	200	20
Hwy 400 NBL Sta 25+140 to 25+750	25+400	East shoulder of Wist Road	200	20
Hwy 400 SBL Sta 24+880 to 25+200	25+050	West shoulder of Davis Road	196	25

* The rod anchor elevation is approximate and should be adjusted in the field to extend approximately 1 m into soils having Standard Penetration Test “N” values of greater than 50 blows per 0.3 m of penetration.

4.2 Materials

The Contractor shall supply all materials and equipment required for the installation of the Benchmarks.

4.2.1 Rod

The Contractor shall supply a steel pipe, Schedule 40, with an outside diameter not less than 25.4 mm, supplied in lengths as required to complete the installation as described in Section 1.3.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

4.2.2 Sand

The Contractor shall supply clean, washed sand. The sand shall be Sakcrete washed general-purpose sand – or equal.

4.2.3 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design shall consist of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU – OPSS 1301).

4.2.4 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design shall consist of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type GU – OPSS 1301).

4.2.5 Friction-Reducing Sleeve

The Contractor shall supply a friction-reducing sleeve consisting of Schedule 40 – 50.8 mm (2") outer diameter PVC pipe cut perpendicular to the axis of the pipe.

4.3 Installation

The Contractor shall install Benchmarks in accordance with the following:

4.3.1 Borehole

The borehole shall be advanced to the rod anchor elevations provided in Table 1 using suitable drilling techniques. The diameter of the borehole shall be sufficient to fit the rod, friction-reducing sleeve and rod anchor. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

4.3.2 Rod

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

4.3.3 Rod Anchor

The rod shall be installed vertically in the borehole with its bottom end resting at the bottom of the borehole. The bottom portion of the rod shall be fixed against the surrounding native soil by grouting the bottom 0.5 m of the borehole to form a concrete/soil anchor.

Once grouting is completed and the rod anchor grout has set, the contractor shall pour clean sand in the lower 0.5 m length of the borehole above the concrete/soil anchor to create a base for the end of the friction reducing sleeve to rest on.

The elevation of the bottom of the rod anchor shall be determined by measuring the length of the rod to the ground surface elevation.

4.3.4 Friction-Reducing Sleeve

The friction-reducing sleeve shall be installed over the entire length of the rod above the rod anchor and sand, extending up to ground surface.

4.3.5 Installation Details

The elevation, easting and northing of the top of the Benchmark rod shall be surveyed.

5.0 MONITORING

5.1 Notification and Reporting

The Contractor shall notify the Contract Administrator no later than three working days after installing a Benchmark. At this time the Contractor shall also supply the following information to the Contract Administrator:

- Northing and easting of each Benchmark, in MTM NAD 83 coordinates;
- Elevation of the rod anchor and top of rod referenced to geodetic datum;
- Dates of installation;
- Stratigraphic log of subsurface conditions at the Benchmarks;
- Installation notes and sketches; and
- Description of the Benchmark, friction-reducing sleeve and rod anchor.

Notification and reporting requirements for all other instruments are provided in the item-specific special provisions.

5.2 Personnel/Access

Data collection, interpretation and reporting shall be conducted by the Contract Administrator or his representative.

The Contractor shall provide access and assistance to the Contract Administrator’s representative reading all geotechnical instruments. This may include, but not necessarily be limited to, the following:

- Safe access to each instrument location;
- A stable platform to support the technician and equipment to access instruments at times when the casing is more than 1.2 m above ground level; and/or
- Power and area lighting.

5.3 Monitoring Program

The Contractor shall meet with the Contract Administrator and staff responsible for the ongoing monitoring immediately after installation of the instruments and before the start of embankment and RSS wall construction. At this meeting, the Contractor shall hand over to the Contract Administrator all records pertaining to the installation of the instruments, and all equipment to be supplied by the Contractor, as identified in the item-specific special provisions.

Monitoring by the Contract Administrator’s representative for the baseline readings shall commence within seven working days after the hand-over meeting. The monitoring shall continue on a schedule to be determined by the Contract Administrator throughout the construction of the embankment widening and RSS wall, and for up to approximately 14 months following the completion of construction to the preload grade.

6.0 DECOMMISSIONING OF INSTRUMENTS

At the end of the monitoring period, the Contractor shall decommission all the temporary survey Benchmarks (BM) by removing the rod and friction-reducing sleeve to at least 1.5 m below grade by excavating and backfilling with compacted granular fill in accordance with the specifications for fill placement.

At the end of the monitoring period, the Contractor shall decommission all Settlement Plates (SP), Settlement Pins (S), Vibrating Wire Piezometers (VWP), Standpipe Piezometers (SSP), Settlement Profilers (PR) and Inclinometers (INC), unless otherwise advised by the Contract Administrator. Decommissioning of instrumentation shall be carried out per the item-specific special provisions and according to the Ontario Water Resources Act, Regulation 903 (as amended).

The Shape Accel Arrays (SAA) shall be kept and protected for long-term monitoring, and shall not be decommissioned.

7.0 MEASUREMENT AND BASIS OF PAYMENT

Payment at the contract price for the above tender items shall include full compensation for all labour, materials and equipment to do the work including the supply and installation of survey benchmarks.

SETTLEMENT PLATES – Item No.

Special Provision

1.0 GENERAL

1.1 Scope

This special provision contains the requirements for the supply and installation of Settlement Plates (SP).

The purpose of the Settlement Plates is to monitor settlements of the embankment/RSS wall base. Settlement is measured by survey of the top of the rod with reference to stable, non-settling Benchmarks. The settlement readings shall help to establish the timing for completion of the preload period.

1.2 General Procedure

The settlement rods shall be attached to a plate at the ground surface following completion of the subexcavation and backfill operations. As embankment or RSS wall construction proceeds, the rods shall be extended above the new top of embankment.

Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod with the plate.

A protective surround shall be extended with the rods as embankment/RSS wall construction proceeds.

As the Settlement Plates are located within the new highway shoulders, the rods shall be cut down to a minimum of 0.3 m below the subgrade level after the monitoring program is complete.

1.3 Location

The Contractor shall install Settlement Plates on the shoulder of the widened Highway 400 embankment, at the locations shown on the Contract Drawings and given in Table 1.

Table 1 – Settlement Plate (SP) Locations

Monitoring Section	Approx. Station	Approx. Elevation of Ground Surface (m) *	Estimated Thickness of Embankment (m)
Hwy 400 NBL Sta 24+800 to 24+830	24+805	223	6
	24+825	223	6
Hwy 400 SBL Sta 24+770 to 24+790	24+770	223	6
	24+790	222	7
Hwy 400 NBL Sta 24+920 to 25+140	24+925	220	6.5
	24+975	219	7
	25+025	219	6
	25+075	219	4.5
	25+125	219	4
Hwy 400 NBL	25+200	219	2.5

Monitoring Section	Approx. Station	Approx. Elevation of Ground Surface (m) *	Estimated Thickness of Embankment (m)
Sta 25+140 to 25+750	25+275	219	<2
	25+350	219	<2
	25+425	219	<2
	25+500	219	<2
	25+575	219	<2
	25+650	219	<2
	25+725	219	<2
Hwy 400 SBL Sta 24+880 to 25+200	24+890	221	5.5
	24+940	221	5.5
	24+990	220	4
	25+040	219.5	4
	25+115	219	2.5
	25+190	219	<2
TOTAL:	**23**		

* Ground surface elevation estimated following completion of subexcavation and backfill operation, prior to start of embankment/RSS wall construction.

2.0 MATERIALS

The Contractor shall supply all materials and equipment required for the installation of the Settlement Plates.

2.1 Plate

The Contractor shall supply a steel plate with thickness of at least 6.35 mm. The plate shall be at least 0.5 m by 0.5 m in plan dimensions.

2.2 Rod

The Contractor shall supply a steel pipe with an outside diameter not less than 25 mm, supplied in lengths as required to complete the installation as described in Section 1.3.

The top end of each rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

2.3 Friction-Reducing Sleeve

The Contractor shall supply a friction-reducing sleeve consisting of Schedule 40 – 50 mm outer diameter PVC pipe cut perpendicular to the axis of the pipe.

2.4 Protective Surround

The Contractor shall supply a protective surround for the portion of the rod and friction-reducing sleeve within the embankment.

The surround shall consist of 300 mm diameter corrugated steel pipe (CSP – OPSS 1801) with the ends cut perpendicular to the axis of the pipe and free of burrs and sharp edges. The space between the CSP and the friction-reducing sleeve shall be filled with medium to coarse sand.

3.0 INSTALLATION

The Contractor shall install Settlement Plates as shown on the Contract Drawings and the typical installation detail, in addition to what is stated below.

3.1 Settlement Plate

The settlement plate shall be installed horizontally on the ground surface following completion of the subexcavation and backfilling works.

The elevation of the plate shall be surveyed before fill placement commences for the embankment/RSS wall construction.

3.2 Rod

The Settlement Plate rod shall be fixed to the centre of the plate and perpendicular to the plate.

The rod shall be extended in 1.5 m increments as the embankment increases in height.

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

3.3 Friction-Reducing Sleeve

The friction-reducing sleeve shall extend over the entire length of the rod that is below ground and within the embankment fill, except that the cap on top of the Settlement Plate rod shall extend 25 mm above the top of the friction sleeve at all times.

3.4 Protective Surround

The CSP, friction-reducing sleeve and sand surround shall be extended with the rods.

The Settlement Plate rod shall be in the centre of the CSP and friction-reducing sleeve.

The annulus between the CSP and the friction-reducing sleeve shall be filled with sand to a level not higher than the top of the friction-reducing sleeve.

3.5 Installation Details

The elevation, northing and easting of the centre of the base of the plate shall be surveyed by the Contractor.

The elevation, northing and easting of the top of the rod shall be surveyed by the Contractor.

The total distance from the base of the plate to the top of the rod shall be measured and recorded by the Contractor to an accuracy of ± 2 mm or better.

The Contractor is responsible for preventing damage to the settlement rod during the fill placement process. If the rod or extension is damaged during fill placement, the rods, friction-reducing sleeve and protective surround shall be replaced before resuming the fill placement.

4.0 COORDINATION WITH MONITORING

4.1 Notification and Reporting

The Contractor shall notify the Contract Administrator no later than three working days after installing Settlement Plates (SP). At this time the Contractor shall also supply the following information to the Contract Administrator:

- Northing and easting of each Settlement Plate in MTM NAD 83 coordinates;
- Elevation of the plate and top of rod referenced to geodetic datum;
- Dates of installation;
- Installation notes and sketches; and
- Description of the settlement plate, rod and friction-reducing sleeve.

Adjustments in the length of any Settlement Plate rod during ongoing construction activities shall be coordinated with the Contract Administrator to allow surveying by others of the elevation of the top of the rod immediately before and immediately after adjustment. This surveying is necessary to accurately track the settlement data.

4.2 Monitoring

Monitoring of the Settlement Plates shall be carried out by others under the Contract Administrator assignment. Monitoring shall be conducted during the embankment and RSS wall construction, throughout the preloading period, and following completion of the preloading period. The Contractor shall provide access to the Settlement Plates for monitoring including, but not limited to, a scaffolding platform and ladder if required and snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed for reading the instruments.

5.0 REMOVAL/DECOMMISSIONING

After completion of the settlement monitoring period, the settlement rods shall be removed to at least 0.3 m below grade by excavating and cutting of the protective surround, friction-reducing sleeve and rod. The excavations should be backfilled with compacted granular fill in accordance with the specifications for fill placement.

6.0 BASIS OF PAYMENT

Measurement for payment will be made on the basis of the number of units of Settlement Plates (SP) installed, including extension through the fills, and then decommissioned following completion of the monitoring period.

Payment at the Lump Sum price for this tender item shall be full compensation for all labour, equipment and materials to do the work, including all appurtenances, extension through the fills, the required reporting, and decommissioning.

SETTLEMENT PINS – Item No.

Special Provision

1.0 GENERAL

1.1 Scope

This special provision contains the requirements for the supply and installation of Settlement Pins (S).

The purpose of the Settlement Pins is to monitor settlements of the embankment/RSS wall fill. Settlement is measured by survey of the top of the pin with reference to stable, non-settling Benchmarks. The settlement readings shall help to establish the timing for completion of the preload period.

1.2 General Procedure

The Settlement Pins shall be cast into concrete at the top of the embankments/RSS wall, as shown on the Contract Drawings. The concrete will be cast in situ in a hold dug at the locations of the Settlement Pins.

1.3 Location

The Contractor shall install Settlement Pins on the shoulder of the widened Highway 400 embankment, at the locations shown on the Contract Drawings and given in Table 1. In general, the Settlement Pins shall be located on the widened Highway 400 shoulder, within approximately 1 m of the corresponding Settlement Plate (SP) at each of the monitoring stations identified below.

Table 1 – Settlement Pin (S) Locations

Monitoring Section	Approx. Station
Hwy 400 NBL Sta 24+800 to 24+830	24+805
	24+825
Hwy 400 SBL Sta 24+770 to 24+790	24+770
	24+790
Hwy 400 NBL Sta 24+920 to 25+140	24+925
	24+975
	25+025
	25+075
	25+125
Hwy 400 NBL Sta 25+140 to 25+750	25+200
	25+275
	25+350
	25+425
	25+500
	25+575
	25+650
	25+725
Hwy 400 SBL Sta 24+880 to 25+200	24+890
	24+940

Monitoring Section	Approx. Station
	24+990
	25+040
	25+115
	25+190
TOTAL:	**23**

2.0 MATERIALS

The Contractor shall supply all materials and equipment required for the installation of the Settlement Pins.

2.1 Pin

The Contractor shall supply a minimum 25 mm diameter reinforcing steel bar (OPSS.PROV 905), cut 0.4 m long.

The top of the reinforcing steel bar shall be angled or rounded in such a way that a single survey point can be clearly identified and returned to.

2.2 Concrete

The Contractor shall supply concrete (OPSS.PROV 1350) of minimum 25 MPa compressive strength and set time sufficient to secure the Nail Pins within two days of pouring.

3.0 INSTALLATION

The Contractor shall install Settlement Pins as shown on the Contract Drawings and the typical installation detail.

4.0 COORDINATION WITH MONITORING

4.1 Notification and Reporting

The Contractor shall notify the Contract Administrator no later than three working days after installing Nail Pins. At this time the Contractor shall also supply the following information to the Contract Administrator:

- Northing and easting of each Settlement Pin in MTM NAD 83 coordinates;
- Elevation of the Settlement Pin referenced to geodetic datum;
- Dates of installation; and
- Installation notes and sketches.

4.2 Monitoring

Monitoring of the Settlement Pins shall be carried out by others under the Contract Administrator assignment. Monitoring shall be conducted after completion of the embankment and RSS wall construction, throughout the preloading period, and following completion of the preloading period. The Contractor shall provide access to the Settlement Pins for monitoring including, but not limited to snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed for reading the instruments.

5.0 REMOVAL/DECOMMISSIONING

After completion of the settlement monitoring period, the Settlement Pins shall be removed by excavating the concrete surround. The excavations shall be backfilled with compacted granular fill in accordance with the specifications for fill placement.

6.0 BASIS OF PAYMENT

Measurement for payment will be made on the basis of the number of units of Settlement Pins (S) installed and then decommissioned following completion of the monitoring period.

Payment at the Lump Sum price for this tender item shall be full compensation for all labour, equipment and materials to do the work, including all appurtenances and required reporting.

VIBRATING WIRE PIEZOMETER – Item No.

Special Provision

1.0 GENERAL

1.1 Scope

This special provision contains the requirements for the supply and installation of Vibrating Wire Piezometers (VWP).

The purpose of the piezometers is to monitor porewater pressures at depth within the foundation soils. The piezometer readings shall help to confirm the timing for the fill placement for the embankment widening and RSS wall construction, and the timing for completion of the preloading period.

1.2 General Procedure

The piezometers shall be installed in boreholes after completion of the subexcavation and backfilling operations, but prior to any embankment widening or RSS wall construction. The boreholes shall be of sufficient diameter to accommodate installation of the VWP sensor, filter sand and grout.

The VWP signal cables shall be extended out of the embankment widening/RSS wall footprint area through a metal or plastic conduit buried in a trench, as shown in the typical instrument installation details.

Boreholes containing VWP sensors shall be located at least 3 m from other instrument boreholes.

1.3 Locations

The Contractor shall install VWP sensors under the widened Highway 400 embankment shoulder, at the locations and elevations given in Table 1.

Table 1 – Vibrating Wire Piezometer (VWP) Locations and Elevations

Monitoring Section	Approx. Station	Approx. Ground Surface Elevation (m)*	Tip Elevation (m)
Hwy 400 NBL Sta 24+920 to 25+140	24+925	220	212
	24+975	219	210
	25+025	219	208
	25+075	219	208
	25+125	219	205
Hwy 400 SBL Sta 24+880 to 25+200	24+890	221	212
	24+940	221	210
TOTALS:	**7**		

* Ground surface elevation estimated following completion of subexcavation and backfill operation, prior to start of embankment/RSS wall construction.

2.0 MATERIALS

The Contractor shall supply materials and equipment, including drill rigs, required for installation of the Vibrating Wire Piezometers.

2.1 Vibrating Wire Piezometers

The Contractor shall supply VW borehole piezometers by Slope Indicator Model 52611020 (-5 psi to 50 psi), RST model VW2100-0.35 – or equal; compatible with the Slope Indicator Model CR1000 data-logger, RST Model ELGL1200 – or equal. All VW piezometers shall be of the same make and supplier.

All piezometers shall be calibrated prior to installation and the calibration data for each piezometer shall be provided to the Contract Administrator.

2.2 Signal Cable

The Contractor shall supply Slope Indicator Model 50613524 cable, RST Model EL380004 cable – or equal. The length of cable for each piezometer shall be carefully estimated from the Contract Drawings to ensure that there is sufficient additional length of signal cable for each piezometer to provide enough slack in the borehole and along the monitoring trenches to reach the location of each terminal. The cables and terminals shall be protected from construction equipment at all times.

2.3 Bentonite

The Contractor shall supply bentonite in pellet form in sufficient quantity to form borehole plugs as required.

The Contractor shall supply bentonite in powder form in sufficient quantity for the bentonite-cement grout mix for general borehole backfilling.

2.4 Filter Sand

The Contractor shall supply clean washed sand for filter around VW sensors. The sand shall be Sakcrete washed general-purpose sand – or equal.

2.5 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU – OPSS 1301).

2.6 Trench Burial and Conduit

The signal cable for each VWP shall be buried in a shallow trench as shown on the Contract Drawings, to extend outside of the embankment widening/RSS wall construction areas. The Contractor shall supply suitable conduits (e.g. Schedule 40, 75 mm steel pipe or Schedule 80, 75 mm rigid PVC pipe) to protect the signal cables in the trenches and above ground surface. If appropriate, several signal cables may be housed in a single conduit and laid in a common trench.

2.7 Data Acquisition System (Data-Logger)

The signal cables from the vibrating wire piezometers shall be connected to the nearest data-logger, Slope Indicator Model 56701000 (CR1000), RST Model ELGL1200 – or equal. The data-loggers shall consist of the following:

- ENC 16/18 Waterproof Enclosure Model 56705020, Model ELF0638 – or equal;
- SC32A Serial Interface (with RS232 transfer cable) Model 56704010, Model CS-SC32A – or equal;
- VW Interface Model 56701510 or 56701500, Model CS-AVW200 – or equal;
- AM16/32 Multiplexer Model 56702110, Model ELGL2042 – or equal;
- A suitable power supply that shall be able to last for a minimum of 2 years for long term settlement monitoring (i.e. a large capacity rechargeable battery coupled with solar panel);
- LoggerNet Software Model 56708020, Model CS-Loggernet – or equal.

The Contractor shall submit a detailed proposal on the setup of the data-logging system (i.e. numbers and locations of the data-logging unit(s)) to the Contract Administrator for review, prior to ordering the data-logger(s). The Contractor shall program the data-loggers according to the following:

- Recording Software: VWP data shall be recorded two (2) times a day (i.e. one (1) reading every 12 hours); and
- Test Software: Once this program is transferred to the data-logger, the system shall be able to be tested and data recorded manually on site.

The real-time data shall be retrieved on site by direct wire (i.e. RS232 Cable) with a portable laptop computer as specified in the next section.

2.8 Portable Laptop Computer

For the purposes of monitoring the VWPs the Contractor shall supply the following:

- A new Portable Laptop Computer (with a three-year warranty): Intel Core i5 or equivalent (2.4 GHz or higher) with Windows 7 (English), 4 GB memory, a minimum of 250 GB hard drive storage, a DVD+/-RW and Microsoft Office 2010, to retrieve, read and store the VW piezometer readings.
- An extra battery for the above portable laptop computer and a vehicle adaptor for computer charger.

The portable laptop computer will become property of the MTO and shall be handed to the Contract Administrator after the installation of instruments for the monitoring program.

The calibration factors for all vibrating wire piezometers shall be entered in the portable laptop computer by the Contractor for initialization of the instruments.

2.9 Wooden Posts

Wooden posts for the support of the data acquisition system enclosures shall be 100 mm by 100 mm in cross-section, minimum 3 m long pressure treated lumber, installed a minimum of 1.5 m into the ground.

3.0 INSTALLATION

3.1 General

Installation of the VWPs shall be in accordance with the manufacturer's recommendations in addition to what is stated or emphasised below.

3.2 Borehole Installation

The borehole shall be advanced to 300 mm below the tip elevation using suitable drilling techniques. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

The piezometer sensor shall be saturated, per the manufacturer's recommendations. In addition, the borehole shall be filled with water upon installation of the sensor into the base of the hole to maintain saturation of the sensor throughout the installation process.

The piezometer shall be installed according to the typical installation detail shown in the Contract Documents.

3.3 Protection for Long-Term Monitoring (Monitoring Shed)

The data-loggers shall be installed in a walk-in Monitoring Shed to prevent vandalism and minimize exposure of the data-loggers to extreme weather conditions. The Monitoring Shed shall be lockable and weather-resistant. The Monitoring Shed shall be seated on a gravel pad and securely tied down to ground. The location of the Monitoring Shed shall not be susceptible to ground settlement. The Contractor shall submit a detailed proposal of the Monitoring Shed (i.e. materials and locations) to the Contract Administrator for review, prior to construction.

The Contractor shall ensure access to the Monitoring Shed at all times, including but not limited to snow clearing in the winter.

3.4 Completion of Installation

It is known that the process of installing VWPs can temporarily alter the porewater pressure acting on the piezometer tip. The installation of a VWP shall not be considered to be complete until the porewater pressure acting on the piezometer has returned to and stabilized at the value prevailing in the surrounding, unaffected soil mass. The Contractor shall take daily readings of the porewater pressure at each VWP until the value has stabilized. Stabilization shall be deemed to have occurred as follows:

- When no change in the measured value has occurred over a period of five (5) consecutive days and the measured value is within 10 percent of the anticipated hydrostatic value; and
- When the daily rate of change is less than four (4) kPa per day for three (3) consecutive days and the measured value is within 5 percent of the anticipated hydrostatic value.

The Contractor should be prepared to wait for a period of 10 to 15 days after completion of installation of VWPs for the readings to stabilize.

4.0 COORDINATION WITH MONITORING

4.1 Notification and Reporting

The Contractor shall notify the Contract Administrator no later than three working days after the installation of a VWP. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- Northing and easting of each VWP in MTM NAD 83 coordinates;
- Elevations of VW sensors referenced to geodetic datum;
- Dates of installation;
- Stratigraphic log of subsurface conditions;
- Installation notes and sketches;

- Model, make and serial numbers of VWP sensors, readout unit and signal cable; and
- Calibration details of VW sensors.

4.2 Monitoring

Monitoring of the VWPs shall be done by others. The Contractor shall transfer the Portable Laptop Computer to the Contract Administrator, including all the data-logging software and hardware, operation instructions and calibration constants. The contractor shall also transfer the keys for the locks of the Monitoring Shed(s). The Contractor shall be available for an on-site meeting with the Contract Administrator to transfer these items and explain/provide responses to questions from the Contract Administrator regarding the data-logging system.

Monitoring shall be conducted during the embankment widening and RSS wall construction, throughout the preloading period, and following completion of the preloading period. The Contractor shall provide access to the data-loggers for monitoring including, but not limited to, snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed.

5.0 BASIS OF PAYMENT

Measurement for payment will be made on the basis of the number of units of Vibrating Wire Piezometers (VWP) installed.

Payment at the Lump Sum price for this tender item shall be full compensation for all labour, equipment and materials to do the work, including all appurtenances and required reporting.

STANDPIPE PIEZOMETER – Item No.

Special Provision

1.0 GENERAL

1.1 Scope

This special provision contains the requirements for the supply and installation of Standpipe Piezometers.

The purpose of the Standpipe Piezometers is to monitor the groundwater level within the compressible clay deposits, as a reference for the Vibrating Wire Piezometer measurements.

1.2 General Procedure

The Standpipe Piezometers may be installed at any time prior to the start of embankment widening and RSS wall construction.

The Standpipe Piezometers shall be installed in vertical boreholes.

1.3 Location

The Contractor shall install Standpipe Piezometers in areas that will not experience a change in loading (due to either grade raise or excavation). Suggested locations are shown on the Contract Drawings and given in Table 1 below; however, these locations may be adjusted by the Contractor based on their construction activities, subject to approval from the Contract Administrator.

Table 1 – Standpipe Piezometer (SSP) Locations and Elevations

Monitoring Section	Approx. Station	Approx. Ground Surface Elevation (m)	Tip Elevation (m)
Hwy 400 NBL Sta 24+920 to 25+140	24+925 Offset East	220	212
Hwy 400 SBL Sta 24+880 to 25+200	24+850 Offset West	220	212
TOTALS:	**2**		

2.0 MATERIALS

The Contractor shall supply material and equipment, including drill rigs, required for installation of the Standpipe Piezometers.

2.1 Pipe and Couplings

The Contractor shall supply Schedule 40, flush-jointed PVC pipe with an internal diameter no smaller than 19 mm, and appropriate couplings.

2.2 Perforated Section

The Contractor shall supply a 1.5 m long perforated pipe section, consisting of Schedule 40, flush-jointed, 19 mm PVC slotted pipe for each Standpipe Piezometer.

2.3 Bottom Cap

The Contractor shall supply a bottom cap to fit the perforated section.

2.4 Top Caps

The Contractor shall supply vented top caps to fit the pipe.

2.5 Filter Sand

The Contractor shall supply clean washed sand for backfilling around the perforated section. The sand shall be Sakrete washed general purpose sand – or equal.

2.6 Bentonite

The Contractor shall supply bentonite (OPSS 1205) in pellet form for backfilling above the filter sand.

2.7 Grout

The Contractor shall supply cement-bentonite grout for general backfilling. A suitable grout mix design consists of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU – OPSS 1301).

2.8 Protective Housing

The Contractor shall supply a protective housing consisting of a galvanized steel pipe or box section with a minimum internal dimension of 100 mm, equipped with a locking cap to enclose the portion of the standpipe that is above the ground.

3.0 INSTALLATION

Installation of the Standpipe Piezometers shall be as shown on the Contract Drawings in addition to what is stated or emphasised below.

The borehole shall be advanced to 300 mm below the tip elevation using suitable drilling techniques. The sides of the borehole shall be stable and the borehole shall be free of debris.

The Standpipe Piezometers must be of sufficient length above the ground surface to ensure that the anticipated piezometric head is accommodated, and to allow for snow accumulation.

The protective housing shall be cemented in place around the standpipe so as to remain secure and stable throughout the duration of the monitoring.

4.0 COORDINATION WITH MONITORING

4.1 Notification and Reporting

The Contractor shall notify the Contract Administrator no later than three working days after installing Standpipe Piezometers. At this time the Contractor shall also supply the following information to the Contract Administrator:

- Northings and eastings of each Standpipe Piezometer in MTM NAD 83 coordinates;
- Elevation of the ground surface at the Standpipe Piezometer location, referenced to geodetic datum;
- Dates of installation;
- Stratigraphic log of subsurface conditions at the Standpipe Piezometers;
- Installation/backfilling notes, including the depth of the Standpipe Piezometer screen and filter pack, descriptions of the screen and standpipe, and details regarding the stick-up above ground surface.

4.2 Monitoring

Monitoring of the Standpipe Piezometers shall be done by others. Monitoring shall be conducted during the embankment widening and RSS wall construction, during the preloading period, and for approximately six months following completion of the preloading period. The Contractor shall provide access to the Standpipe Piezometers for monitoring including, but not necessarily limited to, snow clearing in the winter. The contractor shall provide general area lighting as needed for reading the instruments.

5.0 DECOMMISSIONING

After completion of the monitoring period, the Standpipe Piezometers shall be decommissioned in accordance with Ontario Water Resources Act, Regulation 903 (as amended).

5.1 BASIS OF PAYMENT

Measurement for payment will be made on the basis of the number of units of Standpipe Piezometers (SSP) installed and then decommissioned following completion of the monitoring period.

Payment at the Lump Sum price for this tender item shall be full compensation for all labour, equipment and materials to do the work, including all appurtenances, the required reporting, and decommissioning.

SETTLEMENT PROFILER – Item No.

Special Provision

1.0 GENERAL

1.1 Scope

This special provision contains the requirements for the supply and installation of Settlement Profilers (PR).

The purpose of the Settlement Profilers is to monitor settlements under the embankment/RSS wall. The settlement readings shall help to establish the timing for completion of the preload period.

1.2 General Procedure

The Settlement Profilers shall be installed to the target elevations following completion of the subexcavation and backfilling operation, and prior to starting construction of the embankment widening/RSS wall. The system shall be installed in conjunction with inclinometer casing as specified in the Contract Drawings.

The base of the Settlement Profilers shall be installed at the bottom of a borehole drilled to stable ground.

Sensing rings for use in borehole applications are to be installed at desired elevations along the pipe.

The installation phase shall be complete when the surrounding embankment is at the final height for the preloading period, and extension of the pipe system is no longer required.

1.3 Location

The Contractor shall install Settlement Profilers so that they are positioned under the shoulder of the widened Highway 400 embankment, at the approximate locations shown on the Contract Drawings and given in Table 1.

Table 1 – Settlement Profiler (PR) Locations

Monitoring Section	Approx. Station	Approx. Elevation of Base of Settlement Profiler (m) *	Estimated Final Pipe/Casing Length (m) **	Approximate Spacing of Sensing Rings (m)
Hwy 400 NBL Sta 24+920 to 25+140	24+925	205	23	Every 1 m from base to original grade (approx. 15 total)
	25+025	200	25	Every 1 m from base to original grade (approx. 20 total)

Monitoring Section	Approx. Station	Approx. Elevation of Base of Settlement Profiler (m) *	Estimated Final Pipe/Casing Length (m) **	Approximate Spacing of Sensing Rings (m)
Hwy 400 SBL Sta 24+880 to 25+200	24+890	205	23	Every 1 m from base to original grade (approx. 15 total)
	24+940	200	27	Every 1 m from base to original grade (approx. 20 total)
TOTAL:	**4**			

* The actual elevation of the base of the pipe and the sensing rings shall be determined by the Contractor during drilling of the borehole, based on socketing a minimum of 1.5 m into the very dense/hard till deposit.

** The Contractor shall provide an additional 6 m of inclinometer casing and pipe per location to allow for a deeper installation than anticipated.

2.0 MATERIALS

The Contractor shall supply all materials and equipment required, including drill rigs, for the installation of the Settlement Profilers.

2.1 Sensing Rings

The Contractor shall supply sensing rings (stainless steel straps) of Model 02842004 or equal for user-installed rings, or Model 50801800 or equal for factory-installed rings.

2.2 Pipes

The Contractor shall supply 3-inch internal diameter corrugated pipes of Model 50801600 or equal for use with 70 mm inclinometer casing.

2.3 Couplings and End Caps

The Contractor shall connect the pipe segments using 3-inch internal diameter couplings of Model 50801602 or equal. The couplings shall be sealed using mastic tape of Model 51003800 or equal, as per manufacturer’s specifications. An end cap of Model 50801601 or equal shall be used at the bottom of the corrugated pipe.

2.4 Inclinometer Casing

The Contractor shall supply the 70 mm QC inclinometer casing of Model 51150210 and 51150211 or equal. Telescopic sections shall be used to allow axial movement of the inclinometer casing while minimizing distortion due to vertical strain as necessary.

2.5 Grout

The annular space between the corrugated pipe and the borehole shall be filled with grout that has similar strength as the surrounding soil, to be designed by the Contractor. The grout mix shall have a low drying shrinkage.

The Contractor shall submit a grout mix design to the Contract Administrator for information purposes, no later than 15 days prior to the start of installation of the Settlement Profilers.

2.6 Readout Probe

The Contractor shall supply a readout unit with 100 m of cable of Model 50810315 or equal, and Teflon-coated, non-stretch, flat survey tape.

3.0 INSTALLATION

The Contractor shall install Settlement Profilers per the manufacturer's recommendations, in addition to what is shown on the Contract Drawings and the typical installation detail, and stated or emphasized below.

3.1 Boreholes

The boreholes shall be +/- 2 percent of vertical. The boreholes shall be of sufficient diameter to enable installation of the inclinometer casing and pipe and grouting of the annular space between the pipe and borehole.

The inclinometer casing and pipe socket length shall extend a minimum of 1.5 m into the very dense/hard till material, and shall be confirmed by the Contractor during drilling of the borehole.

3.2 Inclinometer Casing and Pipe

Care shall be taken not to apply torsion to the inclinometer casing or pipe during installation.

The joints in the inclinometer casing shall be wrapped with Denso Petrolatum Tape or equal.

The couplings shall be sealed with Mastic tape at the coupling joint, then wrapped with tape over the coupling; cable-ties shall then be strapped over the taped joints.

When installing and grouting around the inclinometer casing and pipe, the buoyancy force acting on the casing must be balanced. Clean water can be added inside the inclinometer casing or access pipe, but additional force may be required. If so, the force shall be applied below the lowest telescopic section and is ideally applied at the base of the inclinometer casing. The casing or pipe shall not be pushed down from the top as this will cause telescope sections to prematurely contract or collapse, and thus render the telescopic sections unusable.

3.3 Sensing Rings

Sensing rings are fixed to the pipe by the user, or can be factory-installed.

3.4 Grouting

Prior to grouting, the Contractor shall lower the dummy probe to confirm that the probe can reach the bottom of the inclinometer casing.

The annulus between the borehole and pipe shall be grouted up to the existing ground level. All drilling slurry shall be flushed out of the borehole. Grout shall displace any water from the borehole.

Once grouting is completed, the Contractor shall lower the dummy probe to the bottom of the inclinometer casing to confirm that it has been correctly installed.

3.5 Protective Surround

A PVC pipe shall be placed around the inclinometer casing/pipe system to a slightly lower height. The internal diameter of the pipe and its couplings shall be such that the access pipe is free to slide inside, but without excessive play.

A protective surround, consisting of a corrugated steel pipe and sand backfill, shall be placed around the portion of pipes that are above ground.

The above-ground portion of the access pipe shall be greater than 0.3 m in length.

3.6 Extension of Inclinometer Casing and Pipe

As embankment/RSS wall construction proceeds, the inclinometer casing and pipe and the protective surround shall be extended so that they are always above the current ground level.

Each inclinometer casing and pipe shall be inspected by the Contract Administrator following completion of installation and before the start of embankment construction. The Contractor shall re-grout any casings that are found to be loose or where the grout has settled, at no cost to the Owner.

3.7 Protective Housing After Embankment Construction

Following completion of the embankment/RSS wall construction, the protective housing described elsewhere in this special provision shall be cemented in place around the inclinometer casing or access pipe so as to remain secure and stable throughout the duration of the monitoring period.

4.0 COORDINATION WITH MONITORING

4.1 Notification and Reporting

The Contractor shall notify the Contract Administrator no later than three working days after installing Settlement Profilers (PR). At this time the Contractor shall also supply the following information to the Contract Administrator:

- Northing and easting of each Settlement Profiler in MTM NAD 83 coordinates;
- Elevation of the ground level and top of pipe;
- Dates of installation;
- Stratigraphic log of subsurface conditions at the Settlement Profiler location;
- Installation notes and sketches, including socket details, and the depths of the inclinometer casing and pipe; and
- Elevations/depths of the datum and sensing rings.

4.2 Monitoring

Monitoring of the Settlement Profilers shall be carried out by others under the Contract Administrator assignment. Monitoring shall be conducted during the embankment and RSS wall construction, throughout the preloading period, and following completion of the preloading period. The Contractor shall provide access to the Settlement Profilers for monitoring including, but not limited to, a scaffolding platform and ladder if required and snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed for reading the instruments.

5.0 REMOVAL/DECOMMISSIONING

After completion of the settlement monitoring period, the Settlement Profilers shall be decommissioned in accordance with Ontario Water Resources Act, Regulation 903 (as amended).

6.0 BASIS OF PAYMENT

Measurement for payment will be made on the basis of the number of units of Settlement Profilers (PR) installed, including extension through the fills, and then decommissioned following completion of the monitoring period.

Payment at the Lump Sum price for this tender item shall be full compensation for all labour, equipment and materials to do the work, including all appurtenances, extension through the fills, the required reporting, and decommissioning.

INCLINOMETERS – Item No.

Special Provision

1.0 GENERAL

1.1 Scope

This special provision contains the requirements for the supply and installation of Inclinometers (INC).

The purpose of the Inclinometers is to monitor lateral displacements in the foundation soils in front of the retained soil system (RSS) wall.

1.2 General Procedure

The inclinometers shall be installed to the ground surface elevations after completion of the subexcavation and backfilling operation, but prior to beginning the embankment widening/RSS wall construction. As the embankment height increases in lifts, the inclinometer casing shall be extended upward through the embankment fill.

The installation phase shall be complete when the surrounding embankment is at the final design height for the preloading period, and extension of the inclinometer casing is no longer required.

1.3 Location

The Contractor shall install Inclinometers so that they are positioned under the shoulder of the widened Highway 400 embankment, at the approximate locations shown on the Contract Drawings and given in Table 1.

Table 1 – Inclinometer (INC) Locations

Monitoring Section	Approx. Station	Approx. Elevation of Base of Inclinometer (m) *	Estimated Final Pipe/Casing Length (m) **
Hwy 400 NBL Sta 24+920 to 25+140	24+925	205	23
	25+025	200	25
TOTAL:	**2**		

* The actual elevation of the bottom of the inclinometer shall be determined by the Contractor during drilling of the borehole, based on socketing a minimum of 1.5 m into the very dense/hard till deposit.

** The Contractor shall provide an additional 6 m of inclinometer casing per location to allow for a deeper installation than anticipated.

2.0 MATERIALS

The Contractor shall supply all materials and equipment required, including drill rigs, for the installation of the Settlement Profilers.

2.1 Casing and Fittings

The Contractor shall supply inclinometer QC casing, manufactured by Slope Indicator Company or equal. The casing shall be 70 mm outer diameter, Slope Indicator Model 51150210 or 51150211 or equal. Fittings for the casing shall be consistent in manufacturer and system.

2.2 Telescopic Casing Sections

The Contractor shall supply telescopic casing sections of Slope Indicator model 51150220 or equal.

2.3 Splices

If required, the Contractor shall supply splice kits of Slope Indicator Model 51150250 (male) or 51150251 (female) or equal.

2.4 Bottom Caps

The Contractor shall supply bottom caps of Slope Indicator Model 51150230 or equal.

2.5 Top Caps

The Contractor shall supply top caps of Slope Indicator Model 51101500 or equal.

2.6 Grout

The annular space between the inclinometer casing and the borehole shall be filled with grout that has similar strength as the surrounding soil, to be designed by the Contractor. The grout mix shall have a low drying shrinkage.

The Contractor shall submit a grout mix design to the Contract Administrator for information purposes, no later than 15 days prior to the start of installation of the Inclinometers.

2.7 Protective Surround During Embankment Construction

The Contractor shall supply a protective surround for the portion of the inclinometer casing in the embankment during construction. The protective surround shall consist of an inner plastic sleeve to reduce friction, and an outer 300 mm diameter corrugated steel pipe filled with compacted sand.

2.8 Protective Surround During Embankment Construction

The Contractor shall supply a protective housing consisting of galvanized steel pipe or box section with a minimum internal dimension of 100 mm and equipped with a locking cap to enclose the portion of the inclinometer caising that is above ground after construction of the embankment at the inclinometer locations.

3.0 INSTALLATION

The Contractor shall install Inclinometers per the manufacturer’s recommendations, in addition to what is shown on the Contract Drawings and the typical installation detail, and stated or emphasized below.

3.1 Boreholes

The boreholes shall be +/- 2 percent of vertical. The boreholes shall be of sufficient diameter to enable installation of the inclinometer casing and grouting of the annular space between the inclinometer casing and borehole.

The inclinometer casing and pipe socket length shall extend a minimum of 1.5 m into the very dense/hard till material, and shall be confirmed by the Contractor during drilling of the borehole.

3.2 Inclinometer Casing

The A+ inclinometer groove shall be aligned parallel to Highway 400.

The B+ inclinometer groove shall be aligned perpendicular to Highway 400, in the direction away from the median centreline.

The A+ and B+ direction grooves shall be permanently marked and identified on each casing.

Care shall be taken not to apply torsion to the inclinometer casing during installation.

The joints in the inclinometer casing shall be wrapped with Denso Petrolatum Tape or equal.

When installing and grouting around the inclinometer casing, the buoyancy force acting on the casing must be balanced. Clean water can be added inside the inclinometer casing, but additional force may be required. If so, the force shall be applied below the lowest telescopic section and is ideally applied at the base of the inclinometer casing. The casing or pipe shall not be pushed down from the top as this will cause telescope sections to prematurely contract or collapse, and thus render the telescopic sections unusable.

3.3 Telescopic Couplings

Two telescopic couplings shall be included per inclinometer. The couplings shall each accommodate up to 0.15 m of contraction.

The telescopic couplings shall be installed at approximately 4 m and 8 m below existing ground level (to be adjusted for casing lengths after base elevation established).

3.4 Grouting

Prior to grouting, the Contractor shall lower the dummy probe to confirm that all grooves are properly aligned and that the probe can reach the bottom of the inclinometer casing.

The annulus between the borehole and inclinometer casing shall be grouted up to the existing ground level. All drilling slurry shall be flushed out of the borehole. Grout shall displace any water from the borehole.

Once grouting is completed, the Contractor shall lower the dummy probe to the bottom of the inclinometer casing to confirm that it has been correctly installed.

Once the grout has set, the water level inside the casing shall be lowered to approximately 6 m below the ground to prevent freezing.

3.5 Protective Surround

A PVC pipe shall be placed around the inclinometer casing/pipe system to a slightly lower height. The internal diameter of the pipe and its couplings shall be such that the inclinometer casing is free to slide inside but without excessive play. (Note that the outside diameter of Slope Indicator QC casing is larger than 70 mm due to coupling alignment pins.)

A protective surround, consisting of a corrugated steel pipe and sand backfill, shall be placed around the portion of pipes that are above ground.

The above-ground portion of the inclinometer casing shall be greater than 0.3 m in length.

3.6 Extension of Inclinometer

As embankment/RSS wall construction proceeds, the inclinometer casing and the protective surround shall be extended so that they are always above the current ground level.

Each inclinometer casing shall be inspected by the Contract Administrator following completion of installation and before the start of embankment construction. The Contractor shall re-grout any casings that are found to be loose or where the grout has settled, at no cost to the Owner.

3.7 Protective Housing After Embankment Construction

Following completion of the embankment/RSS wall construction, the protective housing described elsewhere in this special provision shall be cemented in place around the inclinometer so as to remain secure and stable throughout the duration of the monitoring period.

4.0 COORDINATION WITH MONITORING

4.1 Notification and Reporting

The Contractor shall notify the Contract Administrator no later than three working days after installing Inclinometers (INC). At this time the Contractor shall also supply the following information to the Contract Administrator:

- Northing and easting of each Inclinometer in MTM NAD 83 coordinates;
- Elevation of the ground level and top of casing;
- Dates of installation;
- Magnetic and grid bearings of A+ and B+ groove directions;
- Difference between A-axis bearing and line parallel to Highway 400 centreline;
- Stratigraphic log of subsurface conditions at the Inclinometer locations;
- Installation notes and sketches, including socket details, casing depth, stick-up and telescopic sections, and grouting notes.

4.2 Monitoring

Monitoring of the Inclinometers shall be carried out by others under the Contract Administrator assignment. Monitoring shall be conducted during the embankment and RSS wall construction, throughout the preloading period, and following completion of the preloading period. The Contractor shall provide access to the Inclinometers for monitoring including, but not limited to, a scaffolding platform and ladder if required and snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed for reading the instruments.

5.0 REMOVAL/DECOMMISSIONING

After completion of the settlement monitoring period, the Inclinometers shall be decommissioned in accordance with Ontario Water Resources Act, Regulation 903 (as amended).

6.0 BASIS OF PAYMENT

Measurement for payment will be made on the basis of the number of units of Inclinometers (INC) installed, including extension through the fills, and then decommissioned following completion of the monitoring period.

Payment at the Lump Sum price for this tender item shall be full compensation for all labour, equipment and materials to do the work, including all appurtenances, extension through the fills, the required reporting, and decommissioning.

SHAPE ACCEL ARRAYS – Item No.

Special Provision

1.0 SCOPE

This specification contains the requirements for the supply and installation of Shape Accel Arrays (SAA) and associated Earth Stations (data-logger systems with housing and accessories used to remotely collect data from each SAA).

The purpose of the Shape Accel Arrays is to allow remote monitoring of vertical displacements in the foundation soils under the embankment widening/RSS wall. The settlement readings shall help to establish the timing for completion of the preload period, and shall also be used to monitor the long-term behaviour of the foundation soils under the embankment widening, following completion of construction.

1.1 General Procedure

The Shape Accel Arrays shall be installed horizontally in a shallow trench after completion of the subexcavation and backfilling operation, prior to beginning the embankment widening/RSS wall construction. Each Shape Accel array shall extend from the existing Highway 400 embankment toe, perpendicularly away from the Highway 400 embankment/RSS wall to a fixed survey point located near the ditch beside Wist Road or Davis Road.

1.2 Location

The Contractor shall install Shape Accel Arrays at the approximate locations shown on the Contract Drawings and given in Table 1. The Shape Accel Arrays shall be installed with one end under the existing toe of the Highway 400 embankment, after excavating approximately 1 m to 2 m into the existing toe for installation of the trench and SAA. The Shape Accel Arrays will then extend perpendicularly away from the Highway 400 embankment to a fixed survey point located near the ditch beside Wist Road on the east side, and Davis Road on the west side of Highway 400. The fixed survey point shall be selected by the Contractor to be the maximum distance possible from the limit of the Highway 400 embankment widening/RSS wall, without crossing the drainage ditch adjacent to the local road, and in consideration of the Contractor's operations and access.

Table 1 – Shape Accel Array (SAA) Locations

Monitoring Section	Approx. Station (m)*	SAA Length (m)	Segment Length (m)
Hwy 400 NBL Sta 24+920 to 25+140	24+925	12	0.5
	25+025	11	0.5
Hwy 400 SBL	24+890	17	0.5
	24+940	14	0.5
TOTAL:	**4**		

* The actual location of the SAA in plan shall be selected in the field to avoid potential conflict with other monitoring instruments to be installed around this same station under the widened highway embankment shoulder.

** The Contractor shall provide an additional 5 m of SAA per location to allow for a longer installation than anticipated, should the trench excavation extend more than 1 m into the embankment toe and in order to reach a suitable fixed survey point as selected by the Contractor.

2.0 REFERENCES – not used

3.0 DEFINITIONS – not used

4.0 DESIGN AND SUBMISSION REQUIREMENTS – not used

5.0 MATERIALS

The Contractor shall supply all materials and equipment required for the installation of the Shape Accel Arrays, including Earth Station components.

5.1 Shape Accel Array System

The SAA system shall be an "SAAF" Field Array, for monitoring deformations in the field, as manufactured by Measurand Inc., with contact information as follows:

Measurand Inc.
2111 Hanwell Road, Fredericton, New Brunswick, Canada E3C 1M7

Contact: Christiane Levesque
Telephone: +1 506-462-9119
Email: christiane@measurand.ca

The SAA system shall be constructed to the total lengths shown in the Contract Drawings and specifications, and shall have individual segment lengths of 500 mm.

The Contractor shall supply sufficient cable to route from the reference end of each SAA to the Earth Station(s), compatible with the Measurand Inc. SAA. The cable shall be long enough to provide adequate strain relief.

The Contractor shall supply SAA splice kits manufactured by Measurand Inc., or ScotchCast Signal and Control Cable Inline Splicing Kit 72-N1 manufactured by 3M, for splicing SAA cables if and where this is required. Other splicing kits shall only be used with the SAA manufacturer's approval.

The Contractor shall provide a five-year warranty for each Shape Accel Array system.

5.2 SAA Installation Trench

5.2.1 PVC Conduit

The Contractor shall supply PVC conduit for housing the SAA, with an inside diameter of 27 mm +1 mm/-0.5 mm. The outside diameter shall be 32 mm +/3 1 mm.

5.2.2 Bedding Sand

The Contractor shall supply bedding sand to be placed within the installation trench below and above the conduit containing the SAA. The bedding sand shall meet the material requirements for concrete fine aggregate (OPSS.PROV 1002).

5.2.3 Geotextile

The Contractor shall supply non-woven geotextile meeting the requirements of OPSS 1860 to line the SAA installation trench, with the geotextile dimensioned so that it can be wrapped over top of the bedding sand fill.

5.3 Earth Station (for remote data collection)

5.3.1 Enclosure

The Contractor shall supply a National Electrical Manufacturers Association (NEMA) 4 rated enclosure to house the Earth Station components.

5.3.2 Logger

The Contractor shall supply a CR800, CR1000 or CR3000 logger, manufactured by Campbell Scientific Inc., or equal, for collecting data from the SAA system.

The Contractor shall supply either SAA232 or SAA232-5 logger interface modules to connect the SAA systems to the logger communication ports. Only one interface shall be connected per logger communication port.

5.3.3 Power Supply

The Contractor shall supply a 12 V, 100 Ah deep-cycle absorbed glass mat (AGM) battery to supply power for the logger and SAA system. The battery shall be housed in a separate NEMA 3R rated enclosure.

The Contractor shall supply a solar panel not exceeding 50W of rated power, to charge the battery for the Earth Station, and a 12 V regulator to control battery charging via the solar panel.

The Contractor shall provide a five-year warranty for the power supply system(s).

5.3.4 Communications

The Contractor shall supply a cell network modem to provide a remote communication interface. The modem shall be a CDMA or GPRS type modem with an antenna sufficient to achieve average communication rates of 57 kilobytes per second.

The Contractor shall provide for five years (60 months) of cellular network coverage, from the time of installation of the SAA and Earth Station.

5.3.5 Steel Post

The Contractor shall supply a 50 mm galvanized steel pipe for mounting the Earth Station. The pipe shall be installed below frost depth and extend to at least 2.5 m above the ground surface.

6.0 EQUIPMENT – not used

7.0 CONSTRUCTION

The Contractor shall install Shape Accel Arrays per the manufacturer's handling and installation recommendations, in addition to what is stated or emphasized below.

7.1 Instrument and Conduit Assembly

The PVC conduit shall be assembled in a generally flat area using PVC cement suitable for the temperature and weather conditions.

The SAA reel shall be placed on a reel stand with a minimum height of 0.6 m, and such that the SAA will be pulled from the bottom of the reel.

The SAA shall be pulled into the conduit using a rope or a cable with swivel attachment to eliminate twisting of the SAA.

The end cap shall be glued onto the "existing embankment toe" end of the conduit, at the eyebolt end of the SAA.

The PEX at the cable end of the SAA shall be secured to the conduit using the set-screw assembly provided in the Manufacturer's SAA installation kit.

7.2 Horizontal Installation in Trench

The SAA and PVC conduit assembly shall be installed into a trench that is no less than 0.3 m deep by 0.3 m wide. The trench shall be extended a minimum of 1 m into the toe of the existing Highway 400 embankment, following completion of the subexcavation and backfilling operation, and prior to commencement of any embankment widening/RSS wall construction operations. The distal end of the trench shall extend to the fixed survey point, such that the trench is constructed perpendicular to the Highway 400 embankment.

The trench shall be lined with geotextile to provide separation between the existing soil/subexcavation backfill, and the bedding sand fill.

A layer of bedding sand shall be placed in the trench above the geotextile. This layer shall be at least 150 mm thick, or the thickness of the largest particle size in the common fill that will be placed above the SAA and PVC conduit, whichever is bigger.

The SAA and PVC conduit assembly shall be placed into the trench on top of the base layer of bedding sand. The reference (cable) end of the SAA shall be attached to the fixed survey point.

A layer of bedding sand shall be placed above the SAA and PVC conduit assembly. This layer shall be at least 150 mm thick, or the thickness shall correspond to the size of the largest particle in the fill that is being placed above the SAA and PVC conduit, whichever is larger.

The geotextile shall be wrapped over top of the bedding sand, such that there is at least 150 mm overlap in the geotextile.

The trench shall then be filled using Granular A or Granular B Type II material (OPSS.PROV 1010).

7.3 Fixed Survey Points

A fixed survey point shall be installed at the reference end of each SAA and PVC conduit. The fixed survey point shall consist of deep, non-settling temporary benchmarks. The approximate elevation for the bottom of each anchor is provided in Table 2.

Table 2 – Fixed Survey Point Locations and Elevations

Approx. Station	Approx. Offset from CL (m)	Approx. Elevation of Bottom of Anchor (m)*	Approx. Length of Rod Incl. Stick-Up (m)*
Hwy 400 NBL 24+925	37 m east	205	15
Hwy 400 NBL 25+025	37 m east	200	20
Hwy 400 SBL 24+890	45 m west	205	15
Hwy 400 SBL 25+050	42 m west	200	20

* The rod anchor elevation is approximate and should be adjusted in the field to extend approximately 1 m to 2 m into soils having Standard Penetration Test “N” values of greater than 50 blows per 0.3 m of penetration.

7.3.1 Materials

The Contractor shall supply all materials and equipment required for the installation of the fixed survey points (Benchmarks).

7.3.1.1 Rod

The Contractor shall supply a steel pipe, Schedule 40, with an outside diameter not less than 25.4 mm, supplied in lengths as required to complete the installation as described in Table 2.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

7.3.1.2 Sand

The Contractor shall supply clean, washed sand. The sand shall be Sakcrete washed general-purpose sand – or equal.

7.3.1.3 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design shall consist of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU – OPSS 1301).

7.3.1.4 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design shall consist of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type GU – OPSS 1301).

7.3.1.5 Friction-Reducing Sleeve

The Contractor shall supply a friction-reducing sleeve consisting of Schedule 40 – 50.8 mm (2") outer diameter PVC pipe cut perpendicular to the axis of the pipe.

7.3.2 Installation

The Contractor shall install Benchmarks in accordance with the following:

7.3.2.1 Borehole

The borehole shall be advanced to the rod anchor elevations provided in Table 2 using suitable drilling techniques. The diameter of the borehole shall be sufficient to fit the rod, friction-reducing sleeve and rod anchor. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

7.3.2.2 Rod

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

7.3.2.3 Rod Anchor

The rod shall be installed vertically in the borehole with its bottom end resting at the bottom of the borehole. The bottom portion of the rod shall be fixed against the surrounding native soil by grouting the bottom 0.5 m of the borehole to form a concrete/soil anchor.

Once grouting is completed and the rod anchor grout has set, the contractor shall pour clean sand in the lower 0.5 m length of the borehole above the concrete/soil anchor to create a base for the end of the friction reducing sleeve to rest on.

The elevation of the bottom of the rod anchor shall be determined by measuring the length of the rod to the ground surface elevation.

7.3.2.4 Friction-Reducing Sleeve

The friction-reducing sleeve shall be installed over the entire length of the rod above the rod anchor and sand, extending up to ground surface.

8.0 QUALITY ASSURANCE

8.1 Development of Web-Based Monitoring Service

The Contractor shall provide and maintain a web-based monitoring service for the Shape Accel Array (SAA) monitoring data throughout the monitoring period under the CA assignment and thereafter following transfer of the SAAs to MTO Foundations Section, for a total duration of five years.

The minimum requirements for the web-based monitoring application shall be as follows:

- The application shall upload the SAA data in raw and/or converted form, and provide any application software necessary to read native files and formats, including a license for application software appropriate for web-based use.
- The application shall integrate the automatic/electronically-collected SAA instrument data with the manually collected survey data at the fixed survey points at the reference end of the SAAs.
- The application shall have secure, password-protected access allowing user access for the Contract Administrator and their Foundation Monitoring consultant, the Contractor, and the MTO.
- The application shall be capable of updating graphs as data becomes available, and shall allow users to graph all data or to allow for comparison of selected monitoring points.
    - The application shall be capable of plotting the following at user-selectable scales:
    - Settlement along the length of each SAA for each monitoring event
    - Settlement versus linear and log time for user-selected points along the length of each SAA, at a minimum corresponding to the following points, and also showing the review and alert levels:
        - The crest of the widened Highway 400 embankment;
        - The mid-point of the widened Highway 400 embankment;
        - The toe of the widened Highway 400 embankment; and
        - The point of maximum settlement along the SAA.
    - Fill height versus time (based on manual input to be entered by others).
    - The application shall provide a comment field tied to each reading that is editable by authorized users.
    - The application shall provide the ability to print reports.

8.2 Coordination With Monitoring

8.2.1 Testing

Each SAA system set-up shall be verified prior to hand-over to the Contract Administrator, in accordance with the requirements of the manufacturer and supplier of the SAA system and loggers.

8.2.2 Notification and Reporting

The Contractor shall notify the Contract Administrator no later than three working days after installing Shape Accel Arrays (SAA). At this time the Contractor shall also supply the following information to the Contract Administrator:

- Northing and easting of the fixed survey point and the end of the SAA/PVC conduit at the existing embankment toe, in MTM NAD 83 coordinates;
- Elevation of the reference end of the SAA and the fixed survey point, referenced to geodetic datum;
- Dates of installation;
- Installation notes and sketches, including the instrument, cable and conduit lengths, installation depth, azimuth direction of X-marks, and azimuth corrections for software;
- Manufacturer calibration sheets and instrument serial numbers; and
- Access and any required licencing for the web-based SAA monitoring application.

8.2.3 Monitoring

Monitoring of the Shape Accel Arrays shall be carried out remotely by others under the Contract Administrator assignment. Monitoring shall be conducted during the embankment and RSS wall construction, throughout the preloading period, and for a six-month period following completion of the preloading period. After this time, long-term remote monitoring of the SAA installations shall be turned over by the Contract Administrator to the Foundations Section of the Ministry of Transportation Ontario; the SAAs and associated Earth Stations (including power supply and communications) shall therefore remain in place for a total period of five years, as outlined in Section 2 of this special provision.

Although the SAAs will be monitored remotely, the Contractor shall provide access to the fixed survey points at the end of the SAAs for surveying purposes, including snow clearing in the winter if required during the periods of embankment and RSS wall construction, preloading, and for six months following preloading.

9.0 MEASUREMENT FOR PAYMENT

Measurement for payment on the number of units of Shape Accel Arrays (SAA) installed shall be by each, as may be revised by Adjusted Plan Quantity.

10.0 BASIS OF PAYMENT

Payment at the contract price for this tender item shall be full compensation for all labour, equipment and materials required to do the work including the associated Earth Stations with power supply, five years of remote communications support, and development of the web-based application for importing and viewing the monitoring data.

MINISTRY OF TRANSPORTATION, ONTARIO

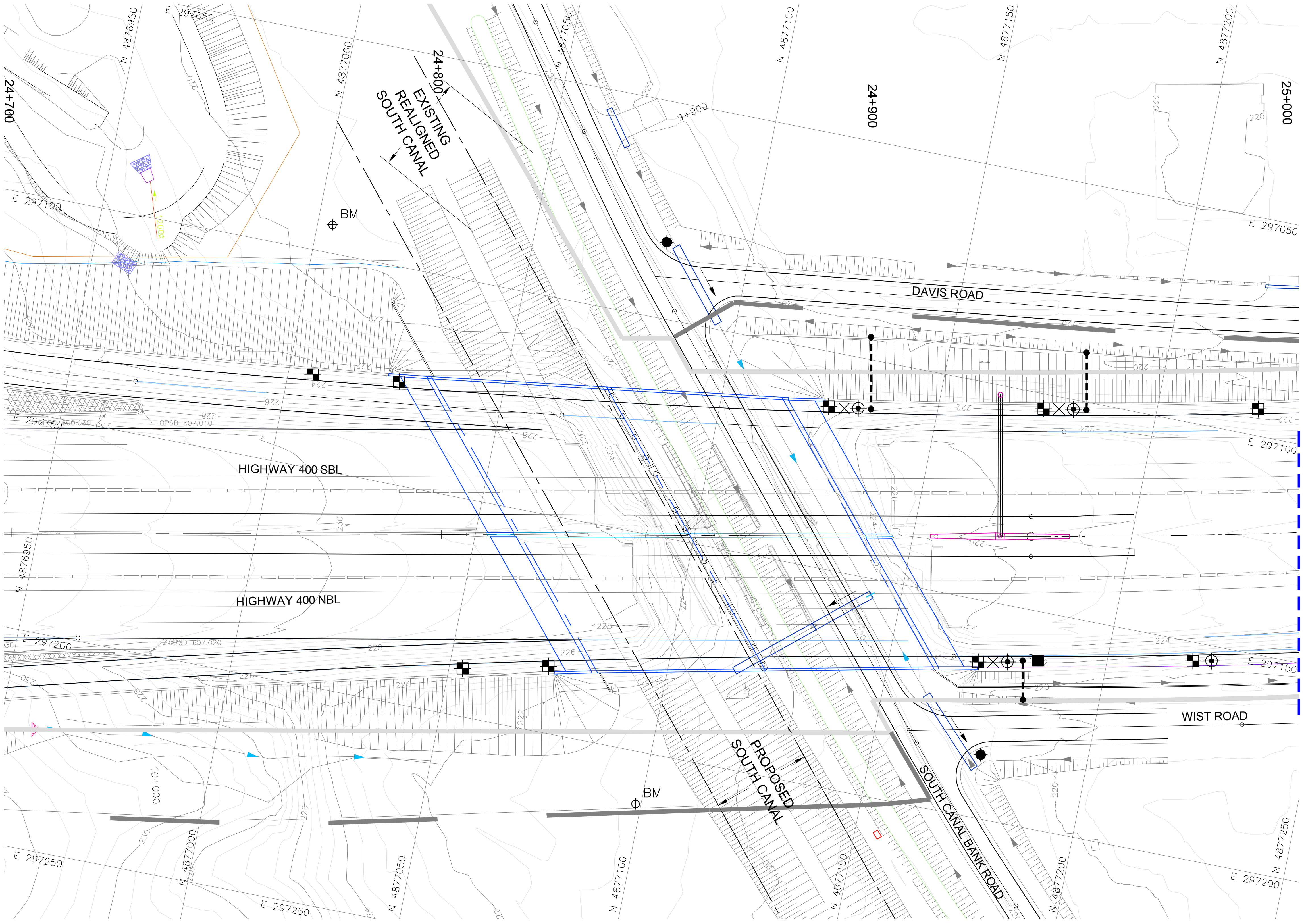
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2015–2004
GWP No. 2025–13–00

HIGHWAY 400 WIDENING
STA 24+700 TO STA 25+000
MONITORING INSTRUMENTATION PLAN

SHEET
531

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



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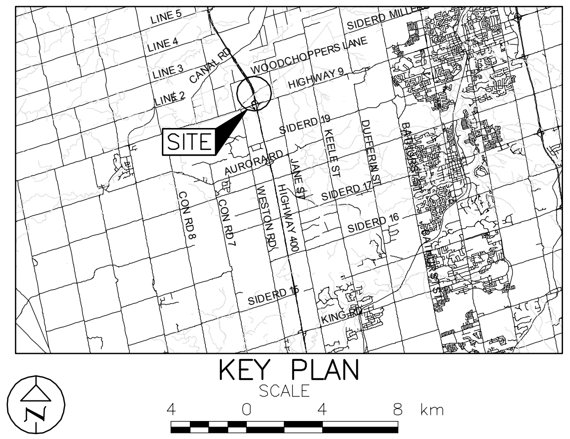


KEY PLAN
SCALE 4 0 4 8 km

LEGEND

⊕	Survey Benchmark (BM)
▚	Settlement Plate and Settlement Pin (SP/S)
⊕	Vibrating Wire Piezometer (VWP)
●	Standpipe Piezometer (SSP)
×	Settlement Profiler (PR)
■	Inclinometer (INC)
●- - -●	Shape Accel Array (SAA)

NOTE
This drawing is for instrumentation layout information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the configuration as shown elsewhere in the Contract Documents.

REFERENCE
Base plans and General Arrangement provided in digital format by URS Canada Inc., (Drawing Files "Hwy400_plan.dwg" and "01_GA_July 10 2012.dwg") received November 13, 2013 and September 26, 2012.

L.C. COYNE
Mar. 10, 2015

J.M.A. COSTA
Mar. 10, 2015

NO.	DATE	BY	REVISION

Geocres No.

HWY. 400		PROJECT NO. 09–1111–0018	DIST. CENTRAL
SUBM'D. MSD	CHKD. LCC	DATE: Mar. 2015	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG. 1

PLOT DATE: March 10, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (URS, York Region)\-UA- Instrumentation\09111110018UA001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

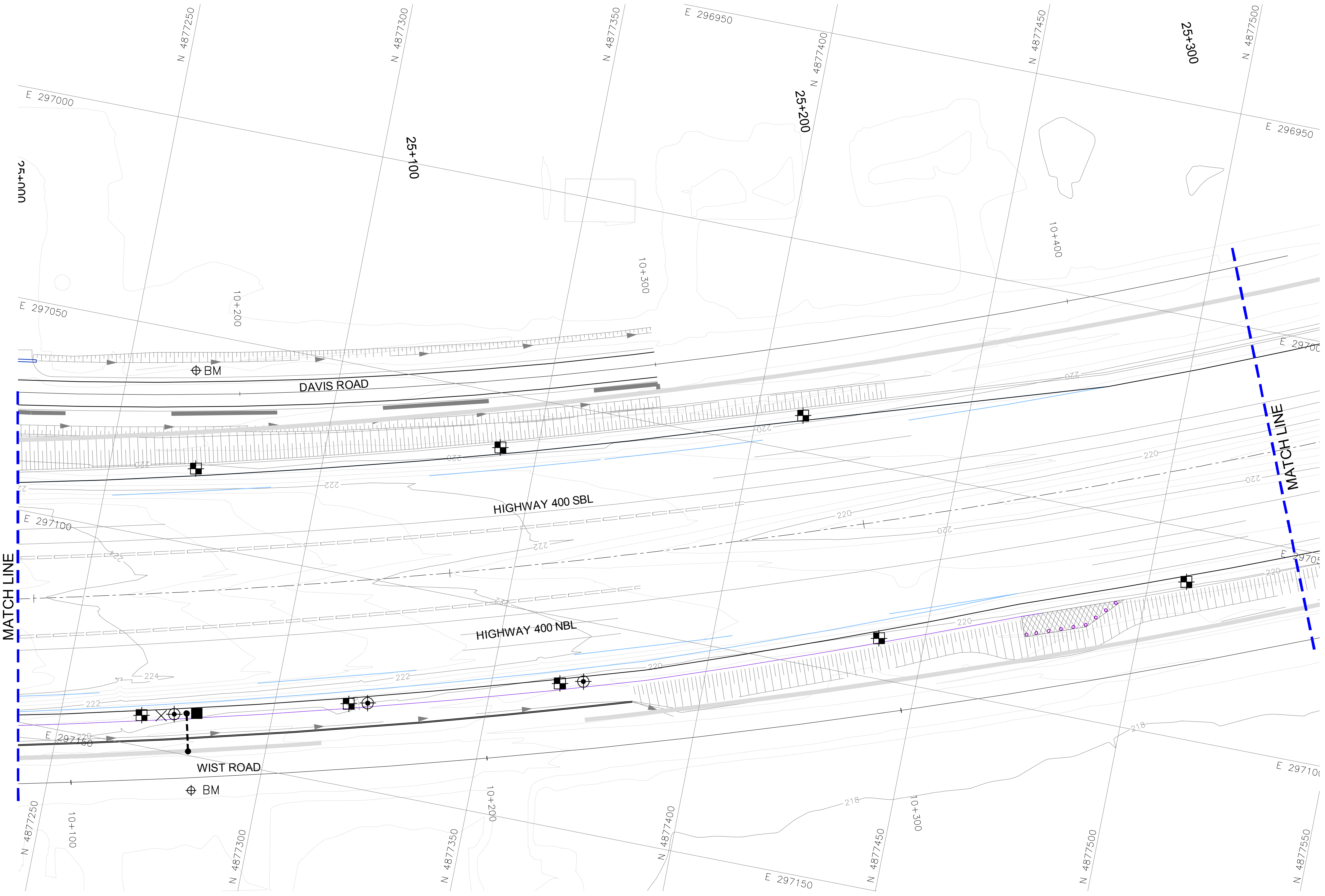
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2015–2004
GWP No. 2025–13–00

HIGHWAY 400 WIDENING
STA 25+000 TO STA 25+300
MONITORING INSTRUMENTATION PLAN

SHEET
532

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



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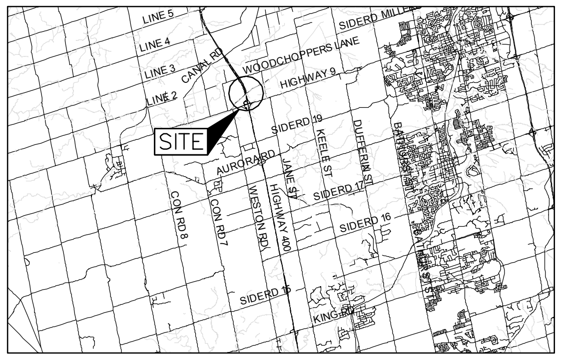

KEY PLAN

SCALE
4 0 4 8 km

LEGEND

⊕	Survey Benchmark (BM)
▚	Settlement Plate and Settlement Pin (SP/S)
⊙	Vibrating Wire Piezometer (VWP)
×	Settlement Profiler (PR)
■	Inclinometer (INC)
●---●	Shape Accel Array (SAA)

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L.C. COYNE
Mar. 10, 2015

J.M.A. COSTA
Mar. 10, 2015

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Geocres No.

HWY. 400		PROJECT NO. 09–1111–0018	DIST. CENTRAL
SUBM'D. MSD	CHKD. LCC	DATE: Mar. 2015	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG. 2

PLOT DATE: March 10, 2015
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MINISTRY OF TRANSPORTATION, ONTARIO

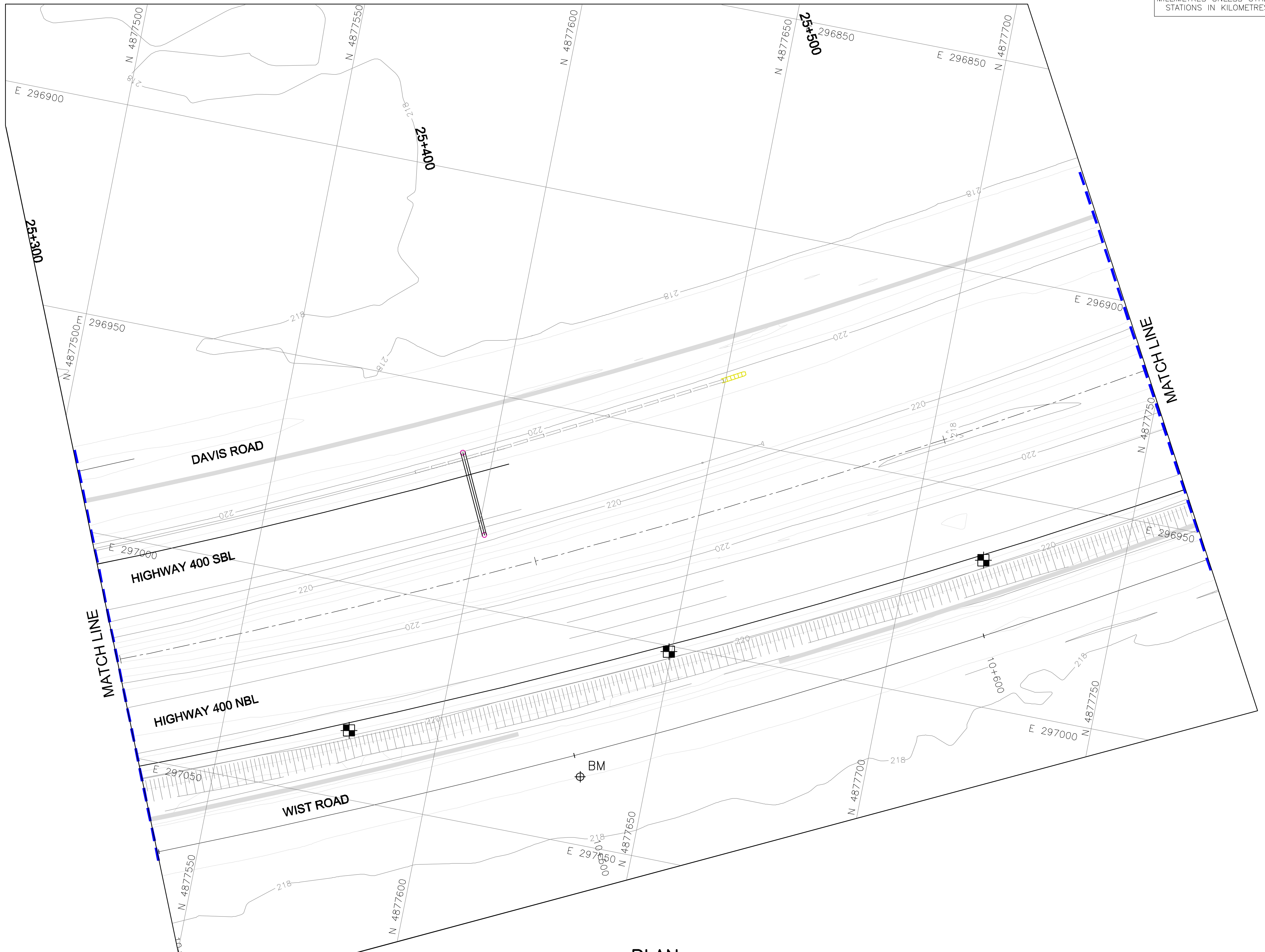
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2015–2004
GWP No. 2025–13–00

SHEET
533

HIGHWAY 400 WIDENING
STA 25+300 TO STA 25+550
MONITORING INSTRUMENTATION PLAN

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN

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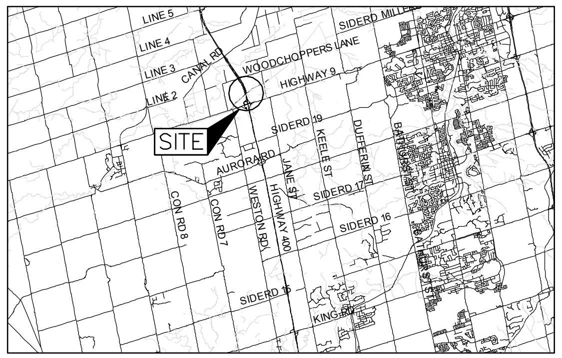

KEY PLAN

SCALE
4 0 4 8 km

LEGEND

⊕	Survey Benchmark (BM)
▞	Settlement Plate and Settlement Pin (SP/S)

NOTE

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L.C. COYNE
Mar. 10, 2015

J.M.A. COSTA
Mar. 10, 2015

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Geocres No.

HWY. 400		PROJECT NO. 09–1111–0018	DIST. CENTRAL
SUBM'D. MSD	CHKD. LCC	DATE: Mar. 2015	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG. 3

PLOT DATE: March 10, 2015
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MINISTRY OF TRANSPORTATION, ONTARIO

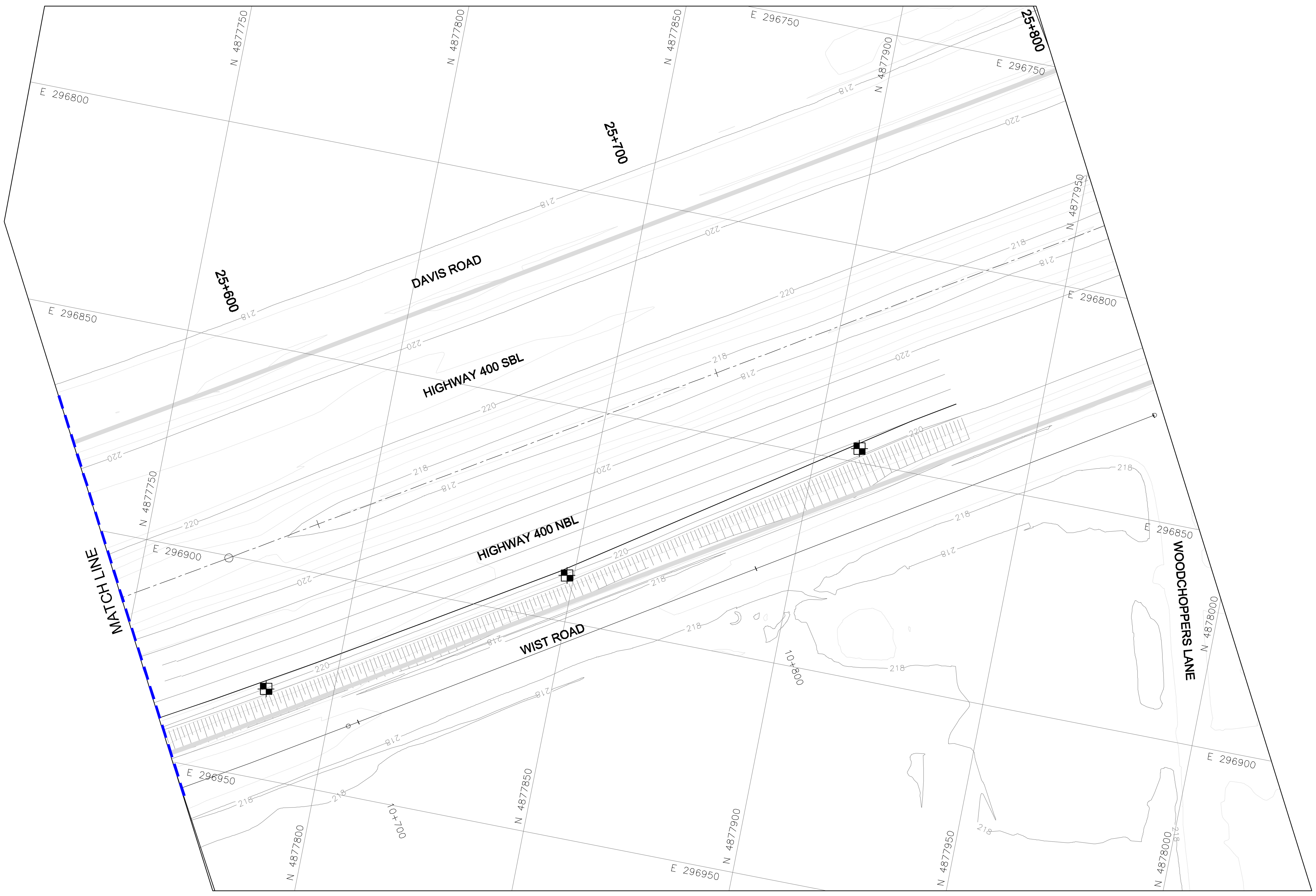
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2015–2004
GWP No. 2025–13–00

HIGHWAY 400 WIDENING
STA 25+550 TO STA 25+800
MONITORING INSTRUMENTATION PLAN

SHEET
534

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



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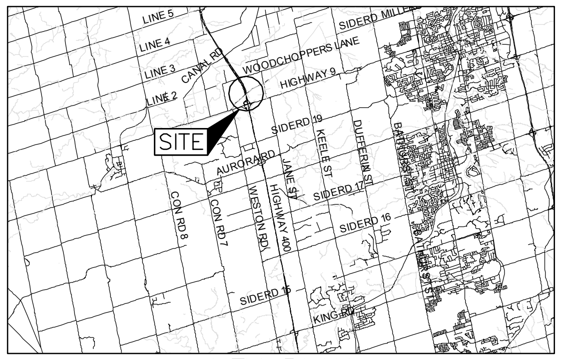

KEY PLAN

SCALE
4 0 4 8 km

LEGEND

▚ Settlement Plate and Settlement Pin (SP/S)

NOTE

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Mar. 10, 2015

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Geocres No.

HWY. 400		PROJECT NO. 09–1111–0018	DIST. CENTRAL
SUBM'D. MSD	CHKD. LCC	DATE: Mar. 2015	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG. 4

PLOT DATE: March 10, 2015
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MINISTRY OF TRANSPORTATION, ONTARIO

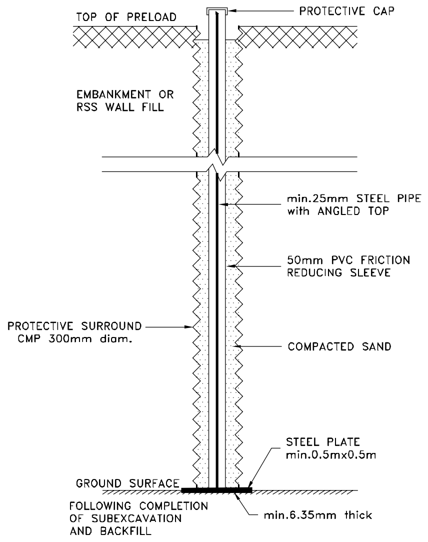
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2015–2004
GWP No. 2025–13–00

HIGHWAY 400 WIDENING
TYPICAL MONITORING AND
INSTRUMENTATION INSTALLATION DETAILS

SHEET
535

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



SETTLEMENT PLATE (SP)
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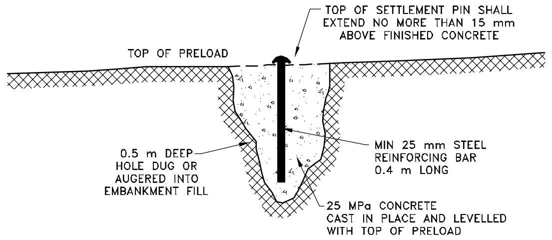

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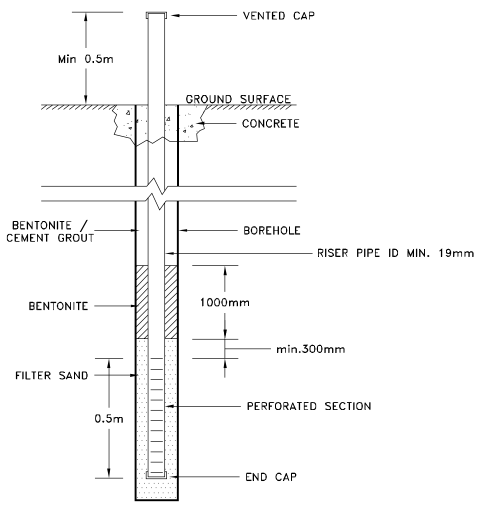

STANDPIPE PIEZOMETER (SSP)
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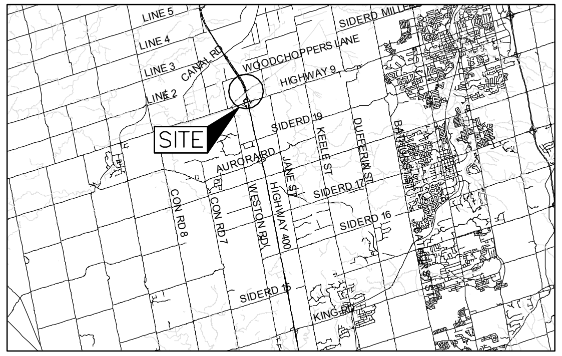
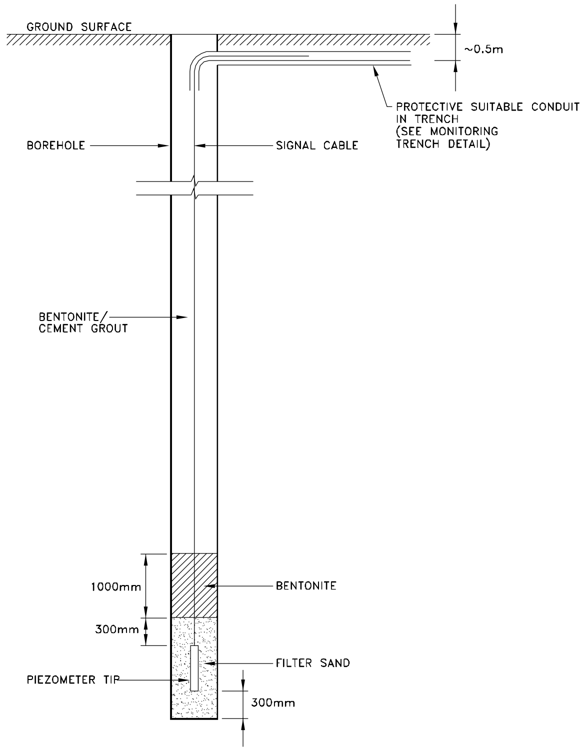


KEY PLAN
SCALE
4 0 4 8 km



VIBRATING WIRE PIEZOMETER (VWP)
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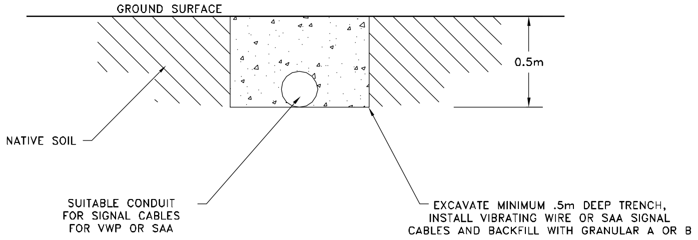

MONITORING TRENCH
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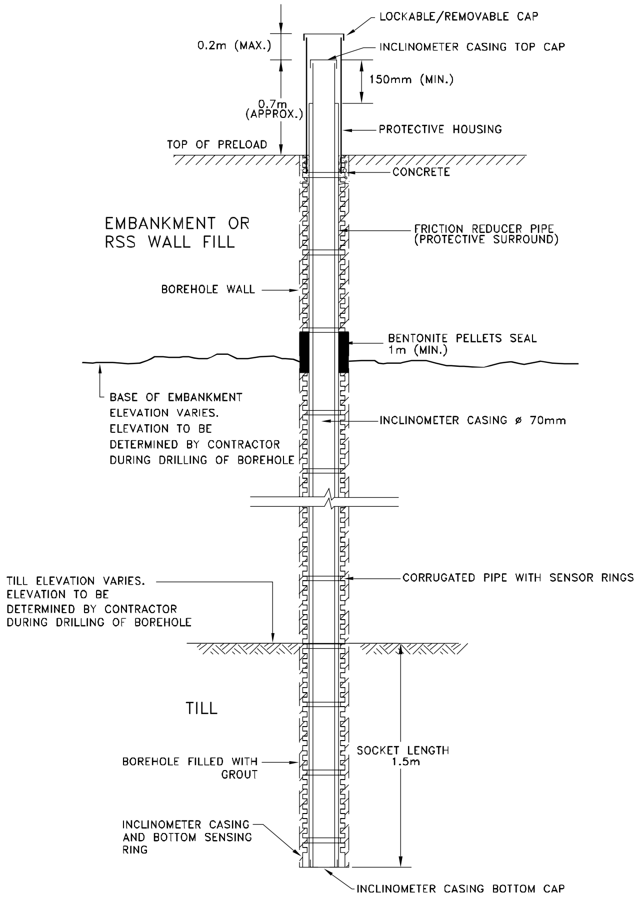

SETTLEMENT PROFILER (PR)
NOT TO SCALE

L.C. COYNE
Mar. 10, 2015

J.M.A. COSTA
Mar. 10, 2015

NO.	DATE	BY	REVISION

Geocres No.

HWY. 400		PROJECT NO. 09–1111–0018	DIST. CENTRAL
SUBM'D. MSD	CHKD. LCC	DATE: Mar. 2015	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG. 5

PLOT DATE: March 11, 2015
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MINISTRY OF TRANSPORTATION, ONTARIO

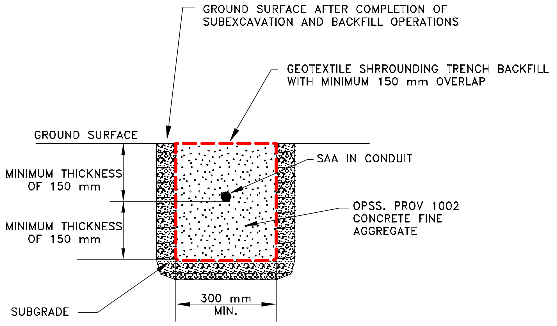
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2015–2004
GWP No. 2025–13–00

HIGHWAY 400 WIDENING
TYPICAL MONITORING AND INSTRUMENTATION INSTALLATION DETAILS

SHEET
536

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



SAA INSTALLATION TRENCH DETAIL

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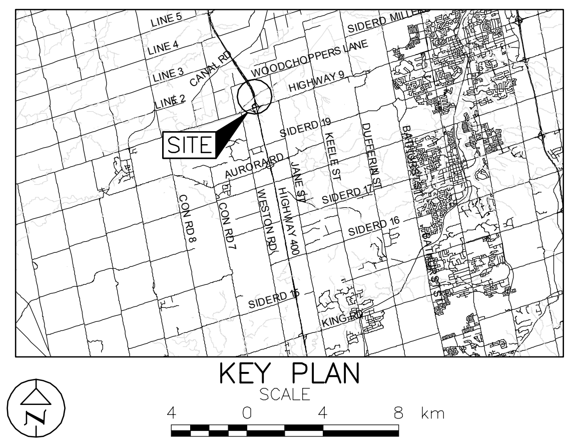
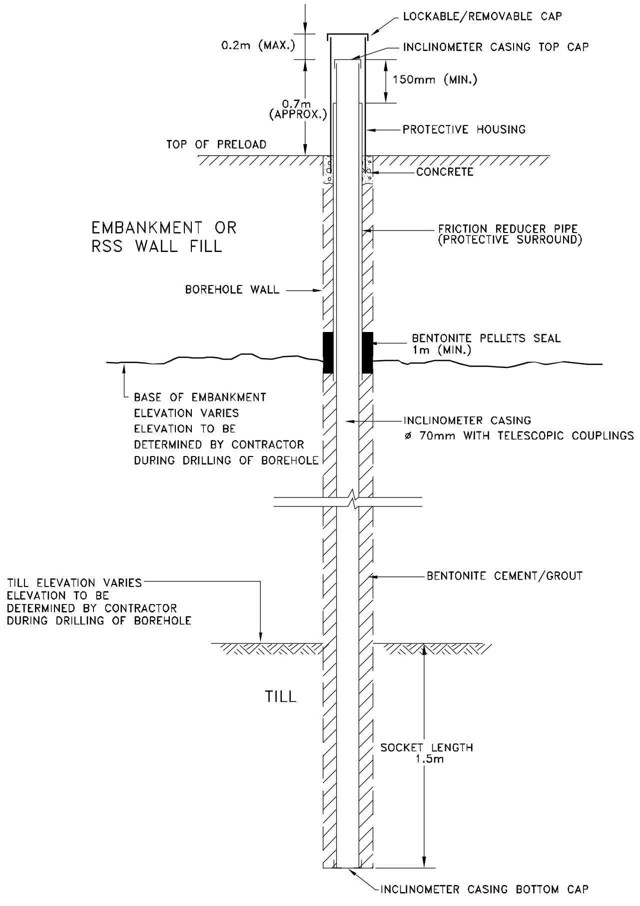
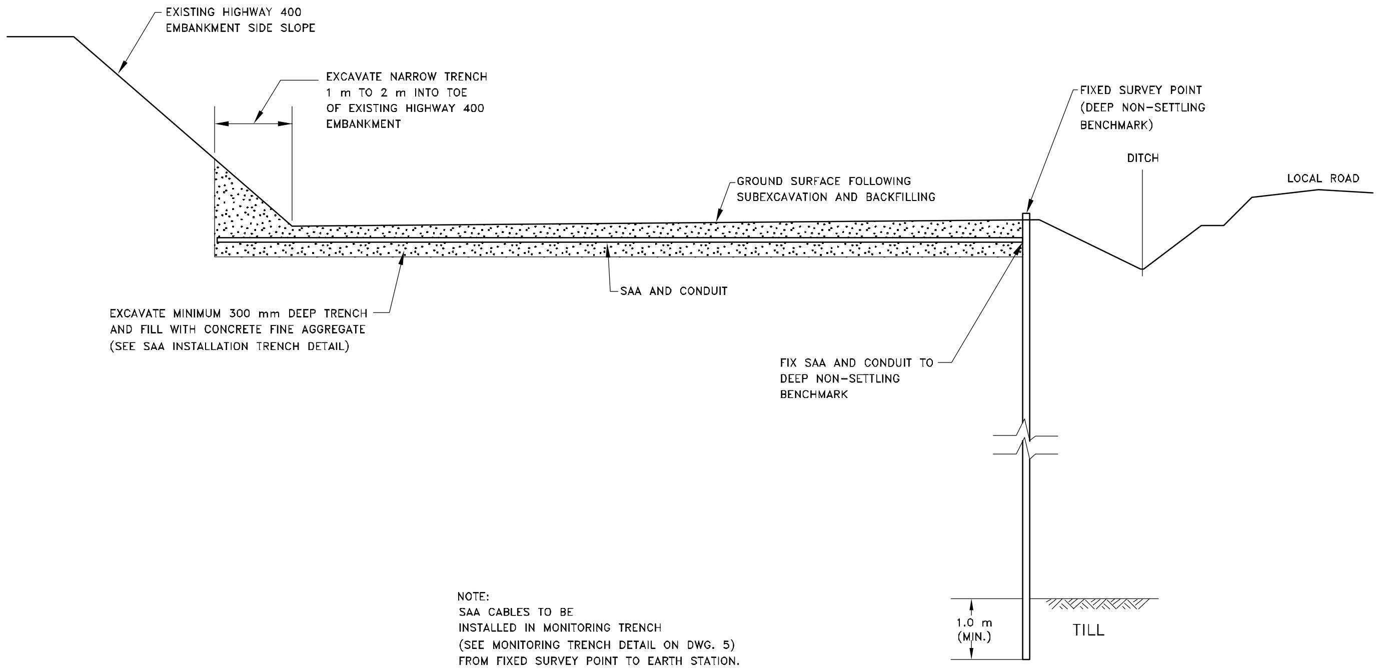


KEY PLAN



INCLINOMETER (INC)

NOT TO SCALE



NOTE:
SAA CABLES TO BE INSTALLED IN MONITORING TRENCH (SEE MONITORING TRENCH DETAIL ON DWG. 5) FROM FIXED SURVEY POINT TO EARTH STATION.

SHAPE ACCEL ARRAY (SAA)

NOT TO SCALE

LICENSED PROFESSIONAL ENGINEER
L.C. COYNE
Mar. 10, 2015
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
J.M.A. COSTA
Mar. 10, 2015
PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No.

HWY. 400		PROJECT NO. 09–1111–0018	DIST. CENTRAL
SUBM'D. MSD	CHKD. LCC	DATE: Mar. 2015	SITE:
DRAWN: JFC	CHKD. LCC	APPD. JMAC	DWG. 6

PLOT DATE: March 11, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (URS, York Region)\-UA- Instrumentation\0911110018UA006.dwg

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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